To Bill Collins
This has excellent models + examples for general ed course — see marked page

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PROCEEDINGS

of

INTERNATIONAL CONFERENCE
1981 ~ ENERGY EDUCATION ~ 1981

Office of Energy Education
and
College of Continuing Education
The University of Rhode Island

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INTRODUCTION

Providence, Rhode Island, USA was the site for the 1981 International Conference of Energy Education. Statistical data for the Conference shows that there were 352 participants from 43 different countries (102 non-USA attendees). There were 168 presentations and 12 workshops by 212 authors and workshop leaders. There were 45 different sessions of which 32 were contributed session, 5 were plenary and 8 were discussion sessions. Educators from all levels, representatives from various professional associations, research scientists, government agency representatives, and industrial, business, and political leaders presented papers on a wide variety of energy education topics.

This Conference provided the vehicle for the information exhange/dissemination and discussions on matters relating to the energy perspective in education. There were many presentations of new and innovative policies and approaches to energy education, and several reports on successful programs at a variety of educational levels. The conference atmosphere was exciting and stimulating for those in attendance. The active participation by the educators, scientists, and others interested in the formal and/or non-formal modes of energy education enabled close working relationships to be established. As these relationships develop, they will substantially increase the effectiveness of concept and information dissemination and the awareness and utilization of existing educational resources and matierials. The formal and informal discussions during the conference enchanced international understanding and cooperation. Networking in this area of education has begun on the National and International levels.

Special thanks go the Organizing Committee and the local host Committee for their efforts to insure that the conference was a success. A furture conference will be held within the next few years, preferably after the International Council of Scientific Unions' Committee on the Teaching of Science Conference in 1985 on Science and Technology Education and Future Human Needs. This conference will contain and energy component.

Donald F. Kirwan and Peter K. Glanz
Editors

SESSION 1: GENERAL ENERGY EDUCATION

1.1 INVITED

EDUCATIONAL PROGRAMS FOR ENERGY LITERACY

Ed. Dalton, President
Energy and Man's Environment
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OUTLINE

1. Rationale for energy education
2. Considerations for implementing energy education programs
   A. Establishing a Point of View
   B. Developing a strategy
3. Components of an effective energy education program
   A. Training/professional programs
   B. Curriculum resources and processes
4. EME as an example of energy education
   A. Purpose
   B. Point of view
   C. Background
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   E. Organizational principles
   F. Organizational goals
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5. Evaluation studies
6. Summary

A RATIONALE FOR ENERGY EDUCATION

Since the oil embargo of 1973, people throughout the world have felt the rising costs of energy and the decreasing availability of some energy resources. Individuals have asked the question: "Why did this occur?" Are we really running out of energy?" "What will our energy future be?"

A national poll, (Cambridge Reports, Inc. 1978) confirmed earlier conclusions that many Americans (40%) do not believe a shortage of energy exists. A survey of adults, (National Assessment of Educational Progress, 1978) ages 26-35, showed that while young adults apparently lack the knowledge to make well-informed decisions on energy issues, they do believe energy-related problems are very serious.

Americans must face the fact that, because of the availability of abundant, cheap energy during the 1950's and 1960's, America produced an enormous stock of capital goods, homes, cars, factories, equipment, and commercial buildings most of which are extremely inefficient users of energy. As the country enters an era of scarce and costly energy fuels, a logical implication of past activities is that *one may expect economic and social changes in all facets of society.*

As in past crises, society has turned toward education for help in changing attitudes, in preparing students for new roles in the work force, and in adapting to new ethics and behaviors consistent with changing social goals and policies. It is now imperative that energy be considered a basic educational theme in all appropriate disciplines and within all grade levels. The following comments illustrate some of the concern being expressed for this objective to be attacines. In February 1978, John Ryor, President of the National Education Association, said in a quest editorial (Energy and Education, February 1978), dealing with energy:

> In a crisis of this proportion, I believe schools ought to be part of a general information program to clarify the problem, explain the government program, and identify the impact both on schools, students, and teachers.

In another reference to energy education, (Energy and Education, April 1978) Edward P. Ortleb, Past President of the National Science Teachers Association, said:

> Students have perhaps been made aware of the energy crisis and some of the technological aspects of it, but we have not helped give them an in-depth feeling for the humanistic factors involved. Each of us must make an effort to become informed. We need the opportunities for students to interpret the world around them and to help them learn to make intelligent decisions.

Furthermore, James C. Kellett, former Director of The Educational Program Division of the U.S. Department of Energy, has stated (Energy and Education, December 1979):

> No longer is it sufficient to master the basics of physical science to "understand" energy (although it is still necessary). One must master a group of other complex systems of thought involving social science and the arcane science of government. It is tempting to say that grappling with our current energy situation requires wisdom and knowledge tempered and strengthened by experience.

In the document entitled, *Policy Issues in K-12 Energy Education* by the Education Commission of the States, August 1979, this position was taken:

> Schools have an urgent responsibility to include energy-related topics at all levels and in all appropriate disciplines, preferably as a part of an integrated, comprehensive energy education/conservation program, and that other public and private agencies should be called upon to provide technical and other forms of assistance in support of this effort. People need an understanding of the energy "facts of life" and an awareness of the severity of the energy-related problems in order to intelligently decide questions of energy consumption in a way that is consistent with the requirements of the new energy era.

It is evident that we stand on the edge of selecting between energy and environmental alternatives, many of which will limit substantial numbers of options available to future generations of our shared biosphere. As a consequence, the resource decisions which we make or don't make individually and collectively in this generation will substantially influence life on planet Earth for every generation to come.

The role of education in this situation should be an obvious one. Unfortunately, there is only minimal evidence that educators are approaching the energy crisis with appropriate concern, care, or dispatch. Education carries a burden in this society for creating a high level of public competency. This implies an educational experience that produces citizens who can intelligently particpate in determining the standard of living and quality of life for the benefit of human kind, and accept the responsibility for the consequences of their decisions. The alternative, of course, is governmental decree - perhaps the ultimate hallmark of failure in a participatory social-political system. To prevent retreat to ecological disaster and political anarchy, education must accept responsibility for teaching those concepts necessary for survival. Clearly, most educational experiences provided in the formal educational setting are not presently designed to help or instruct students in gaining knowledge or developing the skills and attitudes necessary to cope with energy issues and concerns. Our society has not only failed to instill an "energy-ethic" but also encouraged by example the consumption-ethic. What, then, will renew our educational capital and bring us through this critical crossroads with a legacy of accountability for future generations?

Former HEW Secretary John Gardner has said:

> We are all faced with a series of great opportunities - brilliantly disguised as insoluble problems. Educators can realize the potential of this opportunity in many ways: to help students explore their personal perceptions of energy in their environment; to develop a personal consumption ethic based on problem seeking and solution invention — an eco-ethic; to explore as alternatives the satisfaction and rewards that come from caring — for ourselves, for other living things and for the planet we all share.

As students explore personal perceptions of energy in their environment, and their own values related to those perceptions, they can develop an awareness of their own capabilities, and how they can accept or reject what they perceive.

In order for educators to provide the experiences that will allow their students to gain the knowledge of, and change attitudes toward the complex energy picture, well organized and comprehensive energy education programs must be implemented throughout the country. The following sections of this talk will address one process of establishing and implementing an effective energy education program.

CONSIDERATIONS FOR IMPLEMENTING ENERGY EDUCATION PROGRAMS

Establishing a Point of View

It is readily apparent that educators (and everyone else) will differ widely in their understanding of energy and their commitment to devising programs for its study. Even today many persons will question the reality of an energy crisis. Thus, establishing a positive environment for developing energy-centered learning experiences requires considerable skill and remarkable diplomacy. The task is made even more difficult by a whole array of inter-related problems, principle among which are: (1) an *unfavorable economic situation* limiting the availability of money to do the job, (2) *competition with other "vital" programs* for attention and inclusion in the curricula, (3) a *general feeling among teachers that they already have more to teach than they can or should manage*, and (4) *a militant attitude concerning continuing education or growth experiences* without appropriate incentives. Yet, when an accurate view of the energy dilemma is presented, these and other attendant problems can be overcome.

In most instances, the essential ingredient in successful curriculum activities seems to be FLEXIBILITY. A quick inspection of the rich variety of language and approaches to curriculum construction itself speaks eloquently in favor of avoiding the itinerant security of using single sources, a limited resource base, or adopting a single limiting point of view. Consider drawing a circle of inquiry within which all concerns, ideas, and opinions may be fairly examined. There is a profusion of potentially valuable energy resource and instructional materials spread in incredible disorder over the broadest possible spectrum. A potential problem may be remaining sufficiently organized to take advantage of the opportunity.

Developing a Strategy

The following recommendations we consider useful in initiating any energy education effort. It may be helpful to consider these in a closer perspective. Energy and Man's Environment considers these strategies as its key program design components.

A trust relationship with persons in key positions of influence and decision-making should be established. The success of any new endeavor is often a consequence of the acceptance and encouragement of the persons who have already assembled a power base in the geographic or intellectual area in which you work. The best resources may, therefore, reside among those persons who are already respected and well-established. Effort should be taken to convince them that Energy Education is worth their time and expenditure of effort.

A successful Energy Education Program should make every attempt to compliment rather than compete with existing efforts. No comprehensive energy education program exists at any level. There are, however, many organizations, agencies, and individuals that have devised instructional units, and materials that serve specific needs. Every effort should be made to support and compliment these existing programs rather than subvert or limit their effectiveness. Whenever possible, the innovative persons involved in other efforts should be invited to aid their knowledge and skills to your project. This not only brings proven expertise and experience to the effort, but will accrue the influence of these successful individuals on the Energy Education Program.

Change occurs best when it is initiated at both the top and bottom simultaneously. Change in curriculum and instructional practice occurs very slowly and only with great effort. Short of a crisis that lasts for an extended period of time, curriculum modifications occur most successfully when they are initiated at both instructor and administrative levels. The administrator, without the support of his/her curriculum specialists and teachers, will probably fail. An individual teacher may do an outstanding job behind his/her closed classroom door, but without administrative support it is unlikely that even excellent ideas implemented in the individual room will receive system-wide attention or adoption.

Include everyone in — exclude no one. Many persons and organizations will be able to contribute substantially to the success of your program. Don't overlook any sector. Principal groups might include, environmental organizations, resource management agencies, state and local educational specialists, universities, industries, utilities, business, professional associations, research groups, etc. It will come as no surprise that some of the groups with the greatest potential for assistance don't recognize their capacity or the need for their help. A well-organized, positive presentation will pay surprising dividends. The resources can take many forms — all of which will be important to the success of energy education programs. These include technical-professional expertise, finances, information, planning, management, evaluation, research, and many others. Remember, however, that team members should take part, not take over. Each participant must be given an opportunity to contribute his/her special talent or resources, not to use the energy education program as a platform for advocating a specific point-of-view. The essence of the organizing task is to include everyone in, rather than one that excludes anyone out.

The efficiency (ease) with which energy education program tasks are accomplished is directly related to the preliminary planning and organizing skills. Whatever the methods and strategies used in the specific situation, there should be little if anything left to chance.

Consider the interactions and sensitivities of the people within the institutions with which the energy education program will function. However certain the knowledge is of how the system works, update and refine your understanding by making a status check on the situation frequently. Problems are generally people problems.

Only performance ultimately counts. A workable timeline with status and performance check points ultimately is what gives everyone confidence and security.

Learn from the participants. Participants should know that they can influence the process and content of the program. Each must know what kind and in what form contributions are to be positively acknowledged. If innovative ideas and approaches are known to be a prime commodity, there will be an enthusiasm and productivity absent from a narrowly defined, single-track effort.

Appropriate evaluation should be incorporated into all activities of any energy education program. Evaluation is an assessment of the degree or extent to which predetermined and targeted objectives have been obtained. Evaluation is an essential ingredient in maintaining schedule, determining progress, and doing the constant fine adjustments necessary to keep a program on time and on track.

Remember Murphy's Law: "If anything can go wrong, it will." If the energy education program has been planned meticulously, when the inevitable problem arises, it will occur as a single managable situation rather than a difficult or unsolvable crisis.

COMPONENTS OF AN EFFECTIVE ENERGY EDUCATION PROGRAM

An effective energy education program consists of two basic components. Comprehensive in-service program and material and curriculum resources.

In-Service Programs

In-service programs should be designed to accomplish two basic objectives: (1) to create an awareness of the nature and scope of the energy dilemma and its educational implications; (2) to encourage and support the infusion of energy curricula into school instructional programs.

Each in-service program should meet the special needs and interests of the participants. The planning process is an important responsibility that should involve the local community as well as expert guidance by trained professionals.

Several types of programs may be presented to address that above stated objectives:

Administrator/Key Educator Awareness Conferences

Administrators and key educators from all school districts within a region would be invited to participate in this type of conference. The purpose of administrative/key educational awareness conference is to provide the participants with: (1) current data regarding our local, national and regional energy problems, (2) methods to incorporate energy concepts into the curriculum, (3) instructional resource materials available to teach energy concepts, (4) an opportunity for educational leaders to share ideas about energy education and (5) how local school districts can provide inservice program for their staffs. A typical conference would run a full day with one or two keynote speakers and several curriculum sessions.

Implementation Workshops

These workshops usually are a follow-up to administrative/key educator conference. A single school district or school might request an energy education program to meet its specific needs. They should be planned in cooperation with representatives of the local school districts. In this way the district/school gains ownership in the program. These programs usually focus on providing the teachers with some basic energy content, making them aware of instructional resources, and the techniques to use these resources in their classrooms. These programs run two to eight hours and are often done in two or three sessions.

Make and Take Workshops

These workshops are basically for the purposes of constructing energy learning aids for use in the classroom. Several learning aids are discussed and demonstrated, then participants select two or three and construct them. The materials are provided and the teachers have a devise which may be used with their students the next day. These programs usually run about three or four hours. The example of learning aids are electric motors, thermostats, simulations, and other energy games, learning centers, solar dryers, tetrahedron kite, ovens, etc.

Specific Discipline/Content Programs

These programs are provided on a regional basis (several school districts). A specific discipline program might be for home economics teachers and provide background on basic energy concepts that would be useful to these teachers. Curriculum materials and resources specific to this discipline would be made available and teachers would be shown how each may be used. Specific content programs would focus on an energy source or issue. For example, a program might be designed around coal as an energy resource. Both the specific disciplines/content programs usually run about four to six hours.

Summer Projects

Summer projects are often a great help to educators. Common examples of projects are curriculum development activities focusing on a specific topic or discipline, developing slide/tape presentations for use in programs, developing a media/curriculum resources guide for use by local teachers and developing promotional materials to explain programs to other school districts/teachers.

Summer Workshops

These workshops typically last three to five days and involve twenty to forty participants. They may be specific (industrial art teachers) or general (K-12 teachers). They may be held at college/universities and may offer college credit or inservice hours to the participants. The format of the workshop would consist of basic content presentations and techniques for using various instructional materials. Participants would be involved in a curriculum project and would have opportunities to review media materials for classroom use.

A thorough knowledge of program planning and available resources should be brought to all these programs. However, all program planning efforts should be undertaken as a cooperative responsibility of the teachers and the local educational community for whom the program is being developed. In this way, the appropriateness of the program is insured and "ownership" is encouraged on the part of the educational community.

Curriculum Resources

An on-going curriculum development process should be conducted to produce instructional materials for all grade levels and disciplines. The use of many other curriculum resources that are acceptable and appropriate should be encouraged no matter what basic program is being used.

The following sixteen criteria should be used when preparing and/or analyzing curriculum resources:

1. Objectives should be stated.
2. Objectives should be met through suggested activities.
3. The curriculum should be activity oriented.
4. Student assessment methods should be included.
5. The material must be readable.
6. The style and activities are interesting to students.
7. The material educates rather than indoctrinates.
8. Affective as well as cognitive outcomes are sought.
9. The material should be multi-disciplinary.
10. Various levels of difficulty to meet student individual differences should be apparent in the material.
11. Affirmative action should be stressed in pictures and in the text materials.
12. Other resource should be identified.
13. Suggestions to the teachers should be incorporated in the materials.
14. The written text should be factual and accurate.
15. Concepts are not trivial but are really significant.
16. It should be convenient for student and teacher use.

The development of any successful instructional program is a complex and resource-consuming task. Even when the effort is begun within a well-known and established discipline, it is difficult enterprise. When the parameters of the information sources are still to be identified, the process of curriculum building assumes gigantic proportions. Unfortunately, this description is an appropriate image of the current energy situation.

The magnitude of the problem of making instructional sense out of energy should not be construed as sufficient reason to avoid the task. The common interest and personal impact of energy problems provides an unusual opportunity for education to achieve a degree of critically needed renewal. As energy scarcity and costs increasingly influence our personal lives, educators can make the school useful to the parent as well as the child, and by doing so strengthen the concept of life-long learning. By creating inquiry centered learning experiences that bring the parent into the investigation, it is possible to reinforce the kind of relationship that binds the school and home together in preparing youngsters to assume their responsibility as informed decision-makers. By rebuilding parent-educator cooperation and mutual respect, it is possible to blunt the sharp edges of controversy that have cut so deeply into the success of the educational process. In a truly unique way, the study of energy provides a vehicle for bridging the canyon between theory and practice.

Organization

EME developes a wide range of energy-focused resource and instructional materials. The multidisciplinary resources are designed for use in grades K-12, and are intended to be infused into a school district's existing instructional programs. All instructional materials are teacher-made and classroom tested, with technical assistance provided by curriculum and energy specialists. Lesson plans and instructional activity ideas are flexible enough to encourage a variety of teaching strategies, and are easily adapted to meet the particular needs of an individual students or classroom group.

All EME curriculum materials are based upon a carefully conceived conceptual framework of goals, concepts, and objectives. The concept areas include:

1. SOURCES - It is essential that people understand that there are many souces of energy. EME believes that classroom instruction should include a balanced and objective examination of all energy sources.
2. CONVERSIONS - It is essential that people understand that energy can be converted from one form to another. EME believes that an understanding of energy conversions and the laws of thermodynamics are essential to energy literacy.
3. LIMITS - It is essential that people understand that energy resources and their availability for human activity vary. EME believes that knowledge of the earth's energy resources and their availability is fundamental to informed decision making.
4. USES - It is essential that people understand that there are many uses of energy. EME believes that an understanding of energy uses will help learners develop a personal energy ethic.
5. CONSERVATION - It is essential that people understand and value practices which extend the useful life of the earth's energy resources. EME believes that the wise and efficient use of energy and all resources is essential in a finite and interdependent world.
6. IMPACTS - It is essential that people understand that energy development and use creates impacts on environmental and economic systems.
7. FUTURE - It is essential that people understand that our energy future may be different from that of the past or present. EME believes that energy education can help learners understand our responsibility for future generations.

Materials developed related to this structure are:

- Lesson Plan Notebooks
  - Grades K-3
  - Grades 4-6
  - Grades 7-9 Folder
    - Math Packet
    - Vocational Education
    - Industrial Arts
    - Science Packet
    - Social Science
    - Language Arts
  - Grades 10-23 Folders
    - Science Packet
    - Language Arts
    - Math
    - Social Science
    - Industrial Arts
    - Vocational Education
    - Economics
- Activity Guide (6 part)
- EME Conceptual Framework Guide
- Conservation of Energy Activity Guide
- Adventures of Mini-Volts & Wastey Watts (Complete kit for 30 students & 1 teacher)
- Energy E.Q. Test
- Teem Brochure
- Bibliography
- Glossary
- Calendar
- Eye Chart Poster
- Conservation Strips
- Energist Newsletter
- Captain Energy Kits

EME AS AN EXAMPLE OF AN ENERGY EDUCATION PROGRAM

Energy & Man's Environment (EME) is a nonprofit educational corporation supported by business, industry, government, educational agencies, and civic organizations.

Purpose

The purpose of Energy & Man's Environment is to help educators understand the nature and extent of the world and national energy dilemma, and its educational implications. To accomplish this purpose, EME develops and supports educational programs designed to achieve energy literacy. In the belief that "the art of teaching is the art of assisting discovery," EME provides teachers with training, as well as instructional and resource materials. These experiences and tools allow them to assist students to take an active part in making wise choices regarding energy and energy-related issues.

Point of View

EME advocates no particular point of view. As an organization, its primary goal is to ensure that energy facts and issues are presented with balance and objectivity. EME actively supports the work of other organizations in the field of energy education, and welcomes the participation of groups and individuals with similar concern for energy literacy.

Background

Energy and Man's Environment was initiated in 1972 as a curriculm project of state education agencies and energy industries. The limited scope of the initial effort was expanded as the 1973 OPEC oil embargo and educator interest combined to punctuate national vulnerability and emphasize the need for energy literacy.

In 1974, EME initiated two program components which remain central elements of the organization — curriculum development and professional in-service training. Conferences, workshops, and seminars were held through-out the United States, using materials prepared by EME curriculum specialists and energy experts. In 1974, EME became a nonprofit educational corporation.

EME is the nation's leading energy education in-service organization. In 1980, 1,184 instructional programs (conferences, workshops, seminars, and special activities) were conducted for over 69,000 participants. As of August 1981, eighteen states/areas were consortium members.

Organization

The Energy & Man's Environment organization is designed for results. The Board of Directors is composed of members from education, industry, and government. Policy is implemented by the President, who also directs the work of the three divisions of the corporation. The Director of Corporate Development is responsible for identifying and securing new program relationships, fund raising and long range planning. The Director of Curriculum & Materials Development and Evaluation is a specialist in curriculum and instruction. This division is responsible for the development of new instructional resources and the evaluation and revision of existing materials. The Director of Program Operations provides direct and continuing technical assistance and training to EME coordinators and Program Planning and Implementation Committees.

Organizational Principles

The following principles are the foundation upon which the organization was established, and represent the standard against which we judge ourselves and are judged by those we serve:

EME maintains a neutral position on all issues. The organization strives to work with individuals and groups representing all points of view.

EME cooperates with and encourages others engaged in responsible energy education efforts. The need for energy literacy requires an active effort by all those who can contribute.

EME acknowledges change as essential to the accomplishment of its purpose, goals, and objectives. EME programs and materials are in a constant state of evolution and improvement. Each member can contribute to the growth and development of the organization's efforts and resources through positive criticism and ideas.

EME conducts its affairs as a "family." Corporate decisions are made with a view to the support and success of each member in the organization.

EME maintains a consistently positive position. The organization believes that constructive effort is the only path to acceptable issue resolution.

EME conducts its program with academic integrity and objectivity. In essense, EME is a vehicle and forum for the open analysis and scrutiny of energy-focused information, ideas and opionions.

Organizational Goals

Energy & Man's Environment conducts its work within a framework of goals. These goals can be interpreted in a manner which is sensitive to the needs of specific geographic areas and audiences served.

Energy & Man's Environment prepares and assists educators in the implementation of energy concepts in all disciplines and at all grade levels.

Energy & Man's Environment develops instructional and reference materials for use by the groups it serves.

Energy & Man's Environment provides information, resources, and assistance to educators, students, college and university facilities, and the general public.

Energy & Man's Environment provides a channel of communication among the energy industry, education community, government agencies, and the general public.

EME STATE/AREA PROGRAMS AND OPERATIONS

Each member state/area is directed by a coordinator selected from among the educational leadership of the respective state. Supporting each coordinator is a State Program Planning & Implementation Committee. Committee members represent business, industry, government, education and civic organizations. Each state/area organization is responsible for planning and implementing an effective energy education program for its own area. In fulfilling this responsibility, the state/area organization works closely with the local school districts to design in-service training programs and other special projects for teachers and students.

As a result, no state EME area operation is quite like any other. Individual and group creativity, local resources, and local interests combine to develop a unique program in each area. EME national staff provides support, guidance, and assists each state/area organization to find its own best way.

Each state/area coordinator selects and directs with Program Planning and Implementation Committee.

Sponsors & Contributors

EME policy encourages active participation by all groups interested in balanced and objective energy education programs. Educational grants and endorsements have been received from state educational agencies, government organizations, local school authorities and other organizations and groups concerned about our energy and environmental future. In addition to funding, many groups contribute their time, facilities, and other resources in support of EME programs.

EVALUATION STUDIES OF THE EFFECTIVENESS OF EME

Once an energy education program has been developed, the program then should begin considering whether it is meeting the goals that it set out to achieve. Evaluation should be continuous. Efforts to improve should be the highest priority. If energy education programs such as Energy and Man's Environment are to continue, it is essential that the impact on students' energy literacy and whether the program is meeting its goals be determined. One study which examined the effect and impact of EME was conducted in 1980. Specifically, this study determined the "second round effects" of EME students. (The EME program deals primarily with educators as participants in workshops and conferences. As those educators in turn teach their students, what impacts are carried over into the classroom?)

The main purpose of this study was to determine the effect of EME on fifth grade students in two geographical areas. Students were assessed to determine their level of energy knowledge and the level of their attitude towards energy.

The research design used in this study was a casual-comparative design with four groups involved. These were divided into the treatment (EME) group and the nontreatment (control) group. The treatment group included subjects from both Wyoming and Oregon who were students of teachers who had previously participated in an EMEM inservice program. Fifth-grade students in Riverton, Wyoming, and Beaverton, Oregon, made up the treatment group while the nontreatment group was represented by fifth-grade students from Lander, Wyoming, and Salem, Oregon.

A secondary purpose of this study was to compare the results achieved by female and male elementary students on a test of energy literacy. Previous studies had only determined the difference in attitudes of female and male subjects at the secondary and the adult levels. The study by Kuhn of North Carolina determined that secondary school females seemed to exhibit a slightly higher but somewhat inconsistent awareness of the need for energy. Males seemed to be more favorable toward the development of new energy resources.

A total of 301 students, 110 in Wyoming and 191 students in Oregon, took the test for energy literacy. One-hundred seventy-eight were in the treatment group and 123 in the nontreatment group. One-hundred forty-seven students were female while 154 were male.

The "treatment" included the following efforts: Riverton, Wyoming, teachers participated in a 1977 summer EME sponsored university credit course on energy education and this was followed by another similar inservice in 1978. The Oregon teachers began their involvement in Energy and Man's Environment in 1973-74. They piloted and field tested many of the activities now included in the EME curriculum materials. Since then teachers from Beaverton have participated as training leaders for many Energy & Man's Environment inservice efforts in other parts of the state of Oregon. Follow-up activities in Beaverton included the EME Energy Conservaton Corps program and materials and a recent inclusion of energy management practice. Several schools in Beaverton have received follow-up since 1977.

To provide controls for the treatment groups two similar nontreatment cities were chosen. Lander was chosen as the control for Riverton. Teachers in Lander had not participated in an EME program. Both cities are located in the same valley 24 miles apart in central Wyoming. The communities are similar in their socio-economic status, size, and backgrounds. Both Lander and Riverton had had energy related development impacts and similar external impacts. Likewise, teachers in Salem, Oregon, a community 50 miles away, similar in demographic characteristics to Beaverton, had not participated in an EME program. Salem was, therefore, chosen as a control community for the Beaverton program.

The instrument used to asses the goals of energy literacy was developed by Dr. Mike Coffey of Denver, Colorado (1980). The instrument was designed with the purpose of measuring both energy knowledge and attitudes toward energy. Thus, the instrument was a measure of energy literacy. The instrument was validated with fifth-grade students in an extensive project conducted for that purpose. Items were developed to assess each of the curriculum goals identified for consideration. The items were randomly ordered and arranged into two separate forms of the instrument. Two forms were created for the purpose of conducting a pre-post test assessment in the process of establishing reliability. Preliminary validation included administering the instrument to students in Denver, Colorado Springs, and Salt Lake City. Finally reliability of the instrument was established in 1979 in a 9-week pre-post test quasi-experimental study conducted in Fort Collins, Colorado. Efforts in Fort Collins included determining the education impacts of EME in a controlled teaching situation with 559 fifth-grade students.

The results obtained were positive in nature and achieved the purpose set forth. Energy & Man's Environment does have a statistically significant positive influence on the energy literacy of students and this occurs in geographically different areas. Students in the EME treatment cities performed higher on a test of energy literacy than students in otherwise similar cities where no EME programs have been conducted previously. In addition, students in the treatment groups scored higher on both energy attitude and energy knowledge subtests. There was a statistically significant difference in the scores of the treatment subjects and the nontreatment subjects on a test of energy literacy for total score, attitude, and cognitive subtest scores. No significant differences were measured for the responses by the two different states on a test of energy literacy. It was concluded that although the state programs do have differences, both were achieving energy literacy with their students. The Oregon and Wyoming programs have differences in the style in which they are presented but, in essence, they both achieved the EME purpose and goal of energy literacy. It was also shown in this study that females do achieve significantly higher total scores on an instrument measuring energy literacy although it cannot be concluded that this difference is attributable to EME.

The overall results of this study indiciate that EME is achieving its purpose of promoting energy literacy. Students from a community where EME programs have been conducted to achieve higher scores on a test of energy literacy than students residing in a similar non-EME community.

Another study, by Dr. Ed Dalton (1979), was to determine if educational impacts had occurred on educators, mainly teachers and administrators, as a consequence of their participation in an EME workshop between 1974 and 1977. An effort was also made to determine the value of EME services, the nature of EME materials, limiting factors in energy concept incorporation and changes in education caused by energy problems.

It was found that numerous impacts had occurred on teachers, administrators, and students as a result of EME efforts. EME materials were also described and found to be highly valued, widely accepted, and used. Limiting factors were identified and changes in education caused by energy problems predicted.

The study indicated that Energy & Man's Environment's efforts are justified and successful. The combination of quality materials and inservice training will result in implementation and incorporation of energy concepts into a teacher's program of instruction or an administrator's program of work.

Another study conducted by Dr. Daniel Grimes (1981), obtained data by constructing and administering a survey questionaire. The instrument was developed with the assistance from eleven educators. A total of 2,141 K-12 classroom teachers from a population of 20,000 within twelve state regions were selected to participate in the survey. Surveyees were selected from EME's workshop registration list. Of those contacted 824 (38.4%) returned a questionaire. The responses were reported according to elementary and secondary grade level groups and the subject matter area most often taught. A small return was obtained from administrators, curriculum specialists and various secondary subject matter teachers which were categorized as "other." States in which the respondents lived were also reported. The data were evaluated by grade level groupings to determine the educational impact of the EME elementary and secondary K-12 core materials in relationship to their usefulness and effectiveness as instructional tools. All data were evaluated collectively without regard to state-to-state differences.

As a result of obtaining evaluative input from educators through the use of a survey questionaire the following findings and answers to research questions were made:

1. How useful did teachers find EME's core instructional materials in providing a variety of pedagogy and content with which to meet individual differences, such as learner interest, ability, attitude and background of experience?

From the data, it was found that reading level difficulty of material content, the amount of background information provided, and instructional strategies were adequate and appropriate for meeting individual differences of students. Findings also revealed that teachers believed students had a positive attitude about their energy education activity experiences.

It was ascertained that elementary teachers preferred the use of audio visual aide resources, teacher demonstrations and questioning techniques the most, as instructional methods and techniques when teaching about energy whereas secondary teachers preferred lecturing, questioning techniques and teacher demonstration. It was also found that elementary teachers preferred providing independent study activities for students, lecturing, reading and answering questions and concept building activities the least while secondary teachers preferred the student independent practice and role playing the least. However, math teachers preferred lecturing the least as compared to other secondary subject matter teachers. Social science teachers had the least preference for teacher demonstrations and had the highest preference for simulation gaming activities and the use of audio visual aides.

It was found that an important percentage of teachers were not sure as to the reading level difficulty of the instructional activities.

2. To what extent had teachers found the subject matter content within the EME core energy education materials relevant, accurate and free from bias?

Findings revealed that elementary and secondary educators believed the EME instructional activities were relevant to their geographical and respective teaching areas, as well as easily infused into existing curricula. It was also found tht educators perceived the concepts to be valid and the content information to be accurate and objective. Special attention was given to the fact that a notable number of elementary teachers in grades K-6 believed their personal energy knowledge was a limiting factor in preparing for EME energy education activity instruction.

3. What were the opinion of teachers concerning overall design and organization of EME's core instructional materials?

As a result of the research, it was found that educators in all grades preferred and liked the fact that the materials were packaged in a three-ring binder. It was also revealed that teachers believed the materials were well organized for easy entry and exit, that the lesson plan format design was useful and the artwork effective. The findings revealed that secondary educators preferred three-ring binders but would like to have energy education instructional materials organized by energy topics within discipline and subject matter specialty areas. Also, elementary teachers preferred kit-box style packaging in addition to three-ring binders. All teachers perferred book form, folders and packet type packaging design the least.

4. Did teachers believe EME's curriculum framework of goals, concepts and learning objectives were designed and engineered in an educationally logical sequential manner?

Data revealed that grades K-12 respondents perceived the concepts and learning objectives to cover the study of energy and that they were logically and sequentially engineered. It was also found that teachers believed the concepts, lesson objectives and learning activities to be adequate in congruency, clarity and conciseness. Differences between subject matter area teachers were not outstanding.

5. Did teachers find the suggested post assessment procedures prepared for each instructional activity effective when measuring student attainment of the lesson/unit objectives?

Even though educators believed that their students achieved an appreciable amount of awareness and understanding of the energy situation in the United States as a result of the EME learning experiences it was found they perceived the EME assessment procedures to be somewhat or limited in usefulness in helping to make this discovery. However, it was found that an important number of elementary and secondary educators indicated they were not sure as to the usefulness of the assessment procedures and test item bank provided and identified within the materials.

6. To what extent were teachers constrained from implementing EME's core instructional activities because of material and equipment requirments?

As a result of the study it was found that elementary and secondary educators believed that material and equipment required to successfully conduct EME energy activities were often available and seldom a hindering factor. However, a notable difference was found with secondary teachers other than science and social science in that, material and equipment requirements posed problems when implementing EME activities.

SUMMARY

It is evident that... Energy Education needs are real and lasting. Designing programs to meet these needs can be costly, complicated, time consuming, difficult tasks. Curriculum development and implementation require expertise and involvement of many sectors and an adequate funding base. Educators will respond when appropriate programs are provided. EME is an example of an approach to meeting energy education needs. The EME program has bee proven successful.

EME provides all materials at a wholesale rate.
EME materials are economically priced because of large volume printing.
EME is a non-profit educational organization.
EME maintains a close "family" relationship.
EME is cost effective.
EME has extensive expertise in establishing, maintaining, strengthening energy education programs.
EME can organize and implement a program quickly.
EME provides accurate fiscal and program reporting.
EME membership means benefits and financial increase from contributors and large contracts the organization obtains.
EME provides unification and an organized, logical approach.
EME programs have proven effective in many locations.
EME is a partnership between education, government, business and community in behalf of educators and students.
EME utilizes many energy materials from throughout the country.
EME maintains an on-going advisory committee which allows everyone to participate.
EME is teacher/educator developed and operated.
EME has been extensively field tested.
EME maintains a program of on-going revision and evaluation.
EME provides new products and programs that are developed.
EME maintains on-going training programs for coordinators and committees.
EME programs are implemented by colleagues from the same grade levels and disciplines.
EME expects representation on industry and education advisory committees from sponsors.
EME guarantees involvement in curriculum development revisions and projects.
EME people are hard working, have integrity and are easy to work with.

INVITED 1.2

Arizona Energy Education. Bill W. Tillery, *Arizona State U.* — During the past five years, 2,000 Arizona Teachers have completed a course in energy education. The course was made possible through a "multiplier program" called the Portal Program. The operation of the program has revealed additional needs in energy education. Among these is the need for conceptually-based information about energy in the State of Arizona. A monthly publication, *Arizona Energy Education*, was initiated to meet this need. The mailing list grew from 600 in

1978 to about 4,000 in 1981. *Arizona Energy Education* is not a newsletter, but a publication of background concepts, up-to-date information, and teaching activities concerning various science topics as they relate to energy. Individual 12-page issues, for example, have been devoted to such topics as passive solar design, oil shale, wind, fusion, and nuclear waste. Other issues have considered how electric power is produced in Arizona — hydro, petroleum, coal and nuclear. Future issues will consider such topics as solar cooling, hydrogen, utility grid systems, and photovoltaics. The cost of publishing and mailing *Arizona Energy Education* is provided by Arizona Public Service Co. It is mailed free to the community of Arizona educators.

AUTHOR: Bill W. Tillery
TITLE: Arizona Energy Education

ARIZONA ENERGY EDUCATION

There are at least four ways to cause a change in energy utilization. One is to declare martial law and dictate such changes. This is only permissible in times of dire, imminent danger. Second, ordinances and laws can be enacted which require compliance, such as thermostat setting. This is not popular. Third, laws and ordinances can be enacted which require such things as high appliance efficiency and insulation in home construction. These tend to be the least painful because individuals do not have to consciously think about them. However, such requirements are usually implemented at the community level and this is cumbersome. Fourth, understandings can be established at an early age, when minds are receptive and patterns of life are least engrained. This last tactic is the pathway of the Arizona energy education programs.

The department of physics, Arizona State University, has conducted a number of energy education programs for the past six years. All of these programs evolved from, or are part of, a unique interdisciplinary academic-year inservice program in energy education for teachers. It is therefore appropriate that we discuss this program, the portal school program, before discussing one of the "spin-offs," a monthly publication, titled *Arizona Energy Education.*

The Portal School. The Portal school program is a cooperative venture between school districts and Arizona State University. "Portal" means opening. The opening provides a mechanism for school districts to communicate their needs to the university. It provides a means for the university to meet these needs by disseminating knowledge to the schools. We utilize the portal school delivery system since it is a proven, cost-effective means of conducting inservice training. As a general explanation, the portal school system operates as follows:

a. *Portal Leader Selection.* School districts are contacted to discuss their needs in energy education. Potential portal leaders are nominated by school officials. The leaders must be recognized as "master teachers," have a Master's Degree, be open-minded, and have the confidence of their fellow teachers and administrators. The nominated leaders are carefully screened by university faculty.

b. *Summer Institutes.* Potential portal leaders attend an intensive three-week summer institute designed to teach them the concepts of the course and to train them to be a teaching assistant during the academic year. After successful completion of the institute, the leader is certified to conduct activities and assist with local school district inservice courses. Leaders are not charged tuition and they receive three semester hours of graduate credit for completing the program. Their travel, room and board, and other costs are reimbursed.

c. *Fall and Spring Courses.* Upon returning to their school district in the fall, the certified portal leaders work with school officials to attract teachers to the course. The energy course is thus advertised at the "grass-roots" level, within each school. The leaders then conduct the planned activities of the course with the assistance and supervision of univeristy faculty. This supervision ensures that a high level program is maintained. The university requires 16 weekly meetings of two and one-half hours duration for three semester hours of credit. These meetings are generally held in the evenings or directly after school is dismissed in the afternoon. Uniform final examinations are given to all participants. Participants are not charged tuition and portal leaders receive remuneration. Funding for the summer and academic year courses has been from three seperate NSF grants, numerous grants from Arizona Public Service Co. (an investor owned utility), and from university budgets.

Impact. A typical year of operation of the portal school will make the following impact: School administrators will nominate 40 or so portal leaders for the summer institute. About 30 will successfully complete the institute, which is taught by two university professors. An average of 20 teachers will take each of the fall semester courses from portal leaders for a total of 600 teachers. Each teacher teaches about 30 pupils (see Figure below). The pupils, then, are reached with a structured, monitored, and up-to-date energy program for about $3 each.

Spin-offs. The operation and evaluation of the portal school program and informal needs assessments have revealed additional needs in energy education. New programs and projects have been developed to meet these needs. Some of these projects are:

a. Administrator's Conferences. The initial contact with school districts is with the superintendent and his staff. We found that many superintendents were thinking of energy as a topic for their business manager. They were interested in saving energy costs for their district, but had not seriously considered energy education as belonging in the curriculum. We therefore started a series of two-day conferences for teams of administrators (superintendent, curriculum coordinators, and two principals). Such a conference has three parts: 1) establishing the need; what is the energy problem; 2) communication about what energy education resources are available; and, 3) asking each team to design an "action plan" for their district. This year, the administrators have suggested a "follow-up" conference for teams of principles and lead teachers from each district. Funding for the administrators' conferences is provided by Arizona Public Service.

b. Activity Packets. We found that there was no room in the public school curriculum for an energy education course, but that energy education activities could be included with other subject areas — science, social studies, mathematics, and so forth. Furthermore, we found that most available material did not fill local needs. There were no classroom activities, for example, that applied to the State of Arizona. A team of classroom teachers (former portal leaders) was organized to produce a multi-packeted supplement to fill this need. Supported by grants from Arizona Public Service, the multi-packeted supplement has been produced and is now in its second year of field testing. The supplemental packets are titled *Arizona Energy Education Activities*, and are for elementary teachers (K-8).

c. Student Projects. In an effort to encourage more pupil involvement in energy education a state-wide energy fair was initiated. The fair consists of a "poster contest" for the primary grades and "science-fair type activities" for the upper grades. The fair is held in a different shopping mall each year. It is supported by two utilities, Arizona Public Service and the Salt River Project, along with the shopping mall. Several thousand projects were entered last year and the fair received extensive media coverage. Prizes are awarded to winners and certificates to all who enter.

d. Monthly Publication. Informal needs assessments of teachers revealed that teachers lacked information on alternative sources of energy, both in general and as applied to the State of Arizona. They also lacked detailed information on Arizona's present-day energy sources. Since such information may change frequently, we started a monthly publication titled, "Arizona Energy Education." The publication provided an opportunity to maintain contact with former portal class participants, and to provide them with an on-going, current source of information. We will now discuss the publication in more detail.

The Arizona Energy Education. The first issue of *Arizona Energy Education* (AEE) was published in 1978. About 600 copies were mailed to the membership of the Arizona Science Teachers Association. Coupons were provided in each issue so that other teachers could add their names to the mailing list if they were interested. Today, about 4000 teachers subscribe to the publication.

AEE is not a newsletter. It is not concerned with announcing educator's conferences and priting short editorials. Other publications meet this need. AEE provides background concepts, up-to-date information, and teaching activities concerning various topics. Two years ago, for example, some of the topics considered were solar energy, oil shale, fusion, wind, conservation, geothermal, and passive solar. As an example of how AEE provides background and up-to-date information, we will consider the passive solar issue. The meaning of passive solar as an alternative energy source was first discussed in this issue. Concepts of energy flow were then presented in an understandable manner, but assuming no background on the part of the reader. These concepts were then applied to the three basic passive solar designs. The application of each design was considered for the State of Arizona. The issue concluded with a discussion of unique passive solar homes in Arizona. Classroom teaching activities were concerned with separate lessons on conduction, convection, and radiation.

In addition to the science concepts of various energy topics, AEE has presented social studies and economic articles as they relate to energy. Energy boom towns, environmental issues, the socioeconomic benefits of geothermal, and energy vs. food production are some of these topics.

Energy related cartoons and classroom teaching activities are regular features that held the interest of teachers. They provide educationally sound means for the teacher to use in the classroom. Some cartoons are political commentary (e.g., a nuclear fuel reprocessing plant with a "waste not-want not" sign), some are puns (e.g., "you can fuel some of the people some of the time, but you can't fuel all the people all the time"), and some are just fun (e.g., "Your car has a hangover — have you been using gasohol?). Teaching activities range from projects that younger students can do (e.g., which color absorbs more radiant energy) to more complicated activities for secondary students (e.g., calculating if a solar water heater is economically feasible for their home).

Teachers have commented that AEE provides them with information they did not have access to or that they did not know how to find. Last year, for example, AEE had a four part series on present-day energy sources in Arizona — petroleum, coal, hydropower, and nuclear. We will consider how AEE met teachers needs by looking at the coal issue. The coal issue discussed how coal is formed, the composition of coal, where coal is found in Arizona, and how it is used. It included a map of coal mines, how the coal is transported, and where the coal-fired power plants are located (80% of Arizona's electricity is from coal-fired plants). The issue also included a discussion of synfuels from coal, and a discussion of the future of coal; how long Arizona's coal supply will last. Thus, teachers were provided with background concepts, information about Arizona's coal energy supply, information on how coal is and will be utilized, maps and drawings related to Arizona coal production and consumption, and teaching activities. This issue also provided a coupon that teachers could use to obtain a free sample of coal from Arizona Public Service.

The cost of printing and mailing AEE is provided by a grant from Arizona Public Service Company. The cost for preparing camera-ready copy, paper and printing, and bulk mailing 4000 12-page issues nine times a year is about $18,000 a year, or $2000 per issue. This breaks down to 50¢ per copy, including mailing.

We have not conducted a formal evaluation of the impact of AEE. Judging from the letters we receive from teachers, however, and judging form the way the mailing list has grown, we feel that AEE is meeting a need in Arizona energy education. Arizona teachers and their students are learning about energy. The utility company that provides the grant for publishing AEE is pleased because their consumers are learning about energy and about their problems in providing electrical energy. Perhaps there is a need for similar publications in other states as well as Arizona.

ENERGY EDUCATION AND CONSERVATION PROGRAMS PROVIDED BY THE ELECTRIC UTILITY INDUSTRY

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Portland General Electric Company
Portland, Oregon

ABSTRACT

As part of a nationwide effort shared by many electric utilities, Portland General Electric Company is providing various energy education programs. The Company's programs focus on energy literacy and the development of a conservation ethic. In response to the requests of

educators for classroom materials, PGE, and the electric utility industry in general, have developed specific programs and activities geared for students from kindergarten through college. These include classroom presentations, facility tours, printed materials and kits, film libraries, and exhibits and displays for special purposes. Recently, our Company has focused special attention on working with groups of "talented and gifted" students. A creative problem-solving, decision-making process is used to assist these students in better understanding the energy issues they will face. PGE sponsors Energy and Man's Environment — a program of energy curriculum development and teacher workshops — in our service area. This program has expanded from the Pacific Northwest to include 14 states, including your neighbor, New Hampshire. We also participate in educational activities of the Northwest Electric Light and Power Association, the Edison Electric Institute, and the Atomic Industrial Forum's Task Force on Visitor Information Centers, among others. We cooperate with local utilities in sponsoring a summer Energy Institute for teachers at Portland State University and have cooperated with Portland Community College in sponsoring energy programs and activities. Our Conservation Department has developed conservation and consumer education programs for schools and adult education classes. This department also initiated one of the first and most comprehensive home weatherization programs in the nation, solar water heating applications, cogeneration programs, and other conservation measures.

I. INTRODUCTION

Thank you for inviting me to appear at the 1981 International Conference on Energy Education. As a representative of Portland General Electric Company — a Pacific Northwest investor-owned utility — it's not often I have the opportunity to travel to the East Coast.

Most natives look upon our region with envy — and with good reason. We have beautiful scenery and the lowest electric rates in the country. We're fortunate, and we know it.

During the 1950s and '60s, electricity in the Pacific Northwest was in plentiful supply. Low-cost hydroelectric power provided virtually 100 percent of our requirements. But as our needs grew and availability of usable dam sites diminished, we began to develop generating projects using thermal energy.

Even though some of the early projects came on line in or close to schedule, by the mid-'70s construction program began to slip. It affected coal as well as nuclear, in turn affecting the region's power outlook in ways that didn't concern us before. Today we find desperately needed projects running years behind schedule.

Where we entered the '70s confident of our power supply future, we find ourselves in the '80s with potential shortages each and every year of the decade. By 1990, the Pacific Northwest will be short about 1,500 megawatts — some four-and-a-half conventional coal plants. Educating our customers and their children about the wise and efficient use of electricity is more important now than ever before. But it can't stop there, and at Portland General Electric it doesn't.

In 1976, Trojan — Oregon's first and this country's largest nuclear generating plant — went into commercial operation. PGE owns 67-½ percent and operates the plant. People don't let us forget it. Nuclear power education is something we inherited when we decided to build the plant. It takes a good percentage of our time.

In addition to Trojan, PGE generates electricity using coal, oil, natural gas, and hydro dams. We have been involved in research and development programs dealing with solar, wind, geothermal, and small-scale hydro. We feel that we have as aggressive a conservation-/weatherization program for our residential customers as any utility in the U.S. The same goes for our cogeneration program whereby if a residential customer builds his own wind generator or small-scale hydroelectric power plant, for example, we buy back from him any surplus power he generates at current rates.

To concentrate our energy education program on any one issue would be failing a very important and necessary responsibility. We are proud of our program and its diversity. Our customers tell us they appreciate our efforts.

II. BODY

A. What Our Energy Problems Are

Electricity was nearly banned!

If you were to research the newspaper headlines of 1890, you would find that a massive campaign was mounted to prevent electricity from being transmitted into homes or businesses.

This campaign was based on fears of electrocution, explosions of ozone in the air, fire, etc.

Only by the successful electric lighting of the Chicago World's Fair of 1893 was it proved that such fears were unfounded.

However, the publicity generated by this campaign of fear caused doubts to linger in the public mind regarding the safety of electricity. Indeed, even into the 1920's, some electric companies had crews of men whose job was to go around changing light bulbs for homeowners who were afraid to get that close to electric current!

I doubt that any of you have called your local electric company lately to ask for someone to come to your home to change a light bulb! It would certainly be interesting to record the response you might get to such a request.

If you did initiate communcation with the electric company in 1981, indeed, it would probably be to request a service we offer — a water heater wrap, energy audit, weatherization assistance, etc.

Then again, I suppose it is remotely possible that you might also call to complain about your high electric bill!!

Which leads me into a point I hope to impress upon you.

America runs on an energy-based economy. Yet, few topics are so beset with public misconception as the economics of our energy problem.

Changes in the way we view the world around us and our relationship to that world creates conflicts in values:

— Bigger is better.
— Small is beautiful.
— High tech versus low tech.
— A limitless future of abundance versus limits to growth.
— Productivity versus leisure, appreciation of aesthetics, the quality of life.
— A single determined future versus an unplanned, uncontrollable future.

Or, put another way:

— Choice of single-family housing versus compulsory clustered housing.
— Choice of private transportation versus mandatory public transportation.
— Choice of energy-intensive industrial and economic growth versus energy-reduced growth.
— Choice of where you work versus compulsory location, etc.

There is no doubt that the U.S. has many energy problems. Yet, at the same time, we American enjoy better health, better food, better housing, and better working conditions than any of our decendants.[1]
The technological society we have built has brought us luxuries undreamed of by kings of the not too distant past.
Indeed, in the 1930s we were concerned that one-third of our population lived in poverty.
By the 1980s, our technological society had reduced the official government poverty level to less than one-eighth of the nation.
Yet, the mere satisfaction of the material needs for the disadvantaged has not diminished their desire for a greater share of America's affluence.
The same is true of the so-called "third world" countries.
America's high technologies are still our special strength in world trade.
Of course, the only way to increase the standard of living of our people, and of all those of the emerging nations, is in the greater use of energy.
Or, with the more effective management of energy we have now — plus conservation!

The decade of the 80's appears to be a decade of transition — especially in energy.
It is apparently going to be a transition decade of the time between the end of an era of cheap energy, signalled by the OPEC Oil Embargo of 1973, to an uncertain energy future beginning in the 1990s.
In our business, we are constantly grappling with the paradox — is it cheaper to "build a watt" or "save a watt"?

Are people willing to conserve significant amounts of energy in their homes and transporation? Are the renewable resources — solar, wind, etc. — technologically and economically feasible to base our energy future upon? Should the high-tech possibilities, such as the breeder reactor and fusion, be pursued vigorously?

The achievement of general affluence has at least brought us the luxury of providing the transitory decade in which to make policy decisions regarding our nation's energy future. This 10-year "holding pattern" was made possibly by the achievements of the past — development of coal and nuclear power — enough to provide our electrical needs into the 21st Century — if it takes that long.
Under the current political process in the U.S., it takes longer to plan and construct a coal-fired electric generating plant than our entire involvement in World War II! It takes longer to plan and construct a nuclear power plant than our entire space program, from conception to the landing of a man on the moon!
Consequently, a third greater reading about a nuclear power plant being planned for his community will be out of college by the time the plant begins operation![2]
If it takes that long for a single conventional industrial facility to be built, we can only speculate at the length of time it will take for a new technology, such as the fuel cell, solar cells, wind, etc., to be developed and begin making a significant contribution to our electric future. The planning, funding, and building of demonstration plants — fine-tuning and resolving environmental impacts of these new technologies — must occur before the first real commercial applications can occur.

B. Impact of These Problems on the Educational System
Energy has become the primary topic arena where many of these conflicting values are being debated and acted out.
Why is this happening? And why is it happening now — in the 1980s?
I really do not know.

I am afraid it may be because some people have become aware of the essential role energy plays in shaping society. Alter energy production or consumption patterns (up or down) and the society will inevitably change. If you want society to change, fool around with its energy systems.
For whatever choices concerning energy are made (whether by politicians, judges, educators, or just "us folks"), we can be sure the choices will have a great impact on the direction our society heads.

The decade of the '80s is likely to be seen as a "holding pattern" period of transition between the era of cheap and abundant energy and a new era of unknown energy supply and use.
During the transition decade, we are likely to see decisions regarding our future life-style and society hammered out in the energy controversy. We are likely to see decisions on future energy policies based primarily on economics.
We would hope that the education system would develop ways of focusing on such economic and technical factors when teaching about energy and identify and delete nonsubstantive issues that deal with philosophy and social values. The latter issues should be incorporated into the study only after the economic and technical factors are thoroughly understood.

Unfortunately, in our age of specialization, school often represents the last opportunity for most students to see some of the real interconnections of life. Not long after their last degree, both engineers and English teachers are likely to forget the basic interactions between the sciences, art, philosophy, technological progress, and opportunities of the average person.[3]

The basic connection should seem obvious. The sense of promise and hope, the feeling of growth and opportunity that stimulates creativity in one area, has the same effect in others.

The arts, sciences, and personal well-being flourish as one — made possible by the prosperity and growth that provided the education, the stimulation, and the hope which fueled playwrights, philosophers, and inventors.
By looking closely at history, technological development, sociology, the arts, etc., students should realize that man's greatest moments were driven by a future promise — made possible by an expanding economy fueled by the heretofore cheap and abundant energy.

C. What Industry Is Currently Doing in Energy Education and Conservation
PGE has been involved in energy education for about 20 years now.
During the early stages of our program development, the major extent of our program was some tours of our small hydroelectric projects near Portland for school classes and an occasional lecture when requested.
Today we have developed one of the most comprehensive energy education programs in the electric utility industry.

Our program includes:

1. Classroom presentations on the following topics:
   a. Basic generation and distribution principles of electricity;
   b. Conservation;
   c. Alternate energy sources;
   d. Electrical safety;
   e. Careers;
   f. Nuclear power, etc.

2. Tours
We still have tours of our dams and also our other generating plants. Also we have tours of our System Control Center, certain areas of our headquarters complex, and our solar demonstration homes, etc.

3. Film Loan Library
We maintain a free loan film library for teachers and sponsor the *Screen News Digest* film program for teachers.

4. Printed Materials
We have developed printed materials for students and teachers. I have brought a few samples of these materials with me if any of you are interested in having them.

5. Exhibits
We have also developed materials — exhibits and displays and bulletin board materials — for use on special occasions such as an energy fair or science fair, energy day or week, conservation day or week, safety day, or career day. These exhibits and displays are also used for participation at professional educational conferences such as National Science Teachers Association, Oregon Science Teachers Association, Oregon Education Association, Oregon School Boards Association, conferences, etc.
In response to specific requests from students and teachers, we have developed educational materials on specific topics such as conservation, consumer information, and careers. I have brought along a few samples of these materials if any of you are interested in having them.

The above programs are sponsored by our Corporate Educational Services Program. In 1980 these programs and activities reached a total audience of some 32,000 students and teachers.
In addition, we have a Visitors Information Center at our Trojan nuclear plant — a real tourist and educational attraction in our region with World's Fair-class exhibits and displays.
In 1980 some 107,000 people visited our center. Of these visitors, 17,000 took guided tours of the Trojan nuclear plant.
In addition, a staff of professional educators presented programs both at the center's auditorium and to schools in Oregon and southwest Washington. In 1980 the staff presented programs on topics such as conservation, alternate energy sources, and nuclear power to an audience of some 35,000 students and teachers in the schools.
In addition to classroom programs, the Trojan Visitors Information Center offers a free loan film library for teachers; a free loan nuclear science laboratory program for teachers; a mini-library program for school libraries; and exhibits and displays for special occasions and conducts workshops for teachers on topic such as nuclear science, energy audits for homes and schools, and general conservation. In 1980, these materials reached a total audience of some 314,000 students and teachers.
Late in 1980 we also opened a smaller visitors center at our Boardman coal plant.
This visitors information center handles plant tours at Boardman and has exhibits and displays which describe plant operations and the general use of coal to produce electricity.
We feel our industry in general and our Company in particular are more involved in conservation practices than any other segment of society.

Besides the educational services I have already mentioned, our Conservation Services Department also offers for teachers some classroom programs and materials directly related to conservation and consumer education.
These programs are offered to adult groups as well as schools.
Our Company offers one of the nation's leading home conservation/weatherization programs which is also administered by the Conservation Services Department. At the end of April 1981, this department had completed energy audits of almost 30,000 of our residential customers' homes and had completed 16,000 weatherization jobs.
In addition, this department has a staff of professional energy educators who specialize in conservation and consumer education programs in the schools. In 1980, these programs reached a total audience of some 13,000 in the schools.

The Renewable Resources section of this department is active in coordinating parallel or cogeneration projects with our customers. Under this service, we provide support for customers wishing to build a wind generator or small-scale hydro project and sell any surplus power they generate back to us. We buy back from these customers their surplus power at our current residential rates. In 1980, eight wind generators and three small-scale hydro projects were completed by our customers.
Also at the end of 1980 we had over 200 passive solar space heating installations on our system, 150 active solar space heating or water heating installations, and over 700 solar water heating only applications installed on our system.
This section of the Conservation Services Department also presents programs in the schools on renewable resources. In 1980, they reached a school audience of some 2,000.

In addition to the above figures, PGE plans to construct 188 MW of power from renewable resources by the year 2000 — 80 MW from geothermal, 73 MW from wind, and 35 MW from wood waste cogeneration.
I believe that these figures indicate as great a commitment to conservation and use of renewable resources as any company or indeed any other industry in the U.S.

In addition to these services, we are a joint sponsor of the Energy and Man's Environment program. Some of you are probably aware of the EME program — I see that they are conducting a workshop on this conference's program.
For those of you not familiar with the program, EME was initiated in the Pacific Northwest as a cooperative energy education program

funded by private busines and was developed and implemented by educators.
We are very proud of the success achieved by this fine program. It has exceeded our greatest expectations. In 1980, in Oregon, EME conducted Energy Awareness Workshops for some 15,000 classroom teachers. In addition, EME conducted conservation workshops for about 3,000 school building maintenance people, cooks, and bus drivers. The program also involved some 8,000 students in an Energy Conservation Corps activity.

In our view at least, the greatest accomplishment of EME is the fact that it has proved that private business can unite in a cooperative effort with the educational system in a joint effort to improve the energy literacy of our customers. Private enterprise and educators have developed a mutual understanding of each other's viewpoint because of this program. We don't always agree with each other, but we have developed a tolerance for, and even respect of, each system's position because of EME.
In addition, we participate with other utilities of the NELPA organization in their Educational Service Committee's efforts. This committee, made up of members of NELPA companies, is producing energy educational materials related to our specific region of the country. We have electric energy characteristics in the Pacific Northwest unique in that we still have a large base of hydro power, plus we have new regional legislation that provides new direction in energy policy for our region.

We also participate in the national energy education program via the EEI Educational Services Committee. I will describe that committee and its functions more in detail in Section F of this paper.

D. What Industry Needs to Do in Energy Education

As you can probably surmise by now, we feel that a major problem facing the electric utility industry is the lack of public understanding and appreciation of the complex nature of the energy situation and the role that the electric industry must play in providing an adequate and reliable supply of electricity.
That is why the educational service programs I just described have become such an integral part of our entire public information program.
We feel that we must increase public awareness of present and future electric energy needs.
We feel we must increase public awareness of the necessity of the wise and efficient use of electricity and the need to conserve as much as possible!
We feel we must make the public aware of the effect of delays caused by conflicting government regulations on the price and reliability of electricity!
And, we feel that the public should be aware that the careful use of electricity can *control*, but may not *reduce* their electric bills.

Today's students are tomorrow's consumers and citizens. The attitudes they form during the school years will be carried over into their adult lives. These attitudes will be reflected in the political, economic, and social decisions which they must make. These decisions will affect the future of the electric utility business also.[4]
Profound alterations in our traditional energy patterns and trends are taking place. Rates of energy use, sources of supply, cost relationships, environmental considerations, and energy technologies are all involved in significant changes.
If the freedom to choose the way we live is to continue, all citizens, youths and adults alike, must understand the basic issues and be prepared to make informed, rational decisions.
We are convinced that energy education in the nation's schools and colleges is essential to provide the basis for informed decision-making by sizable segments of youth and adult populations.

We strongly urge that today's students and adults alike need to know something about:

1. The sources of energy;
2. The uses of energy;
3. The conservation of energy;
4. The environmental impacts of energy;
5. The role of energy in the improvement of the environment;
6. The economics of energy; and
7. The limits of energy.

Besides knowing the above-mentioned factors about energy, students and adults need to develop skills in the application of these factors and the determination of their values to arrive at decisions regarding the energy trade-offs that are necessary.
The cost, supplies, and benefits questions regarding our energy decisions must ultimately be answered by the public.
The tools necessary to do the job can be developed through cooperative efforts of the educational system and the business world!

E. What the Education System Needs to Do

When an educator asks me what ought to be taught regarding the energy situation, I implore him to stress economics.
Explaining the financial problems affecting the electric utility industry, the cost of construction, operations, and providing service is a pressing need.
In order for the freedom to choose the way we live to continue — all citizens, students and adults alike, must understand the basic issues and be prepared to make informed, rational decisions. For decisions made about energy today — its supply, social costs, and the tradeoffs necessary — will determine the quality of our life and that of our children for the next several decades.
All the students in school now must be concerned about the energy supply because their future ability to obtain employment will depend on how much energy there is.
Therefore, energy education in the nation's schools should be considered essential in order to provide the basis for informed decision-making citizens of tomorrow.

Since education is a process by which students learn to think, energy education should not seek to impose beliefs, attitudes, or actions on students — even on issues such as energy conservation!
Rather, education should be directed at increasing public understanding of energy choices in the broadest context — by placing factual information within the economic, social, political, and environmental framework of the issue.
An energy education program should attend to all major technical and policy options, including study and evaluation of all technologies.

Only if such an energy education process occurs can future energy decisions be made on an informed basis.
The cost, supplies, benefit, and questions regarding our energy decisions must ultimately be answered by the public.
This puts the responsibility of teaching energy facts and teaching skills in decision-making processes squarely in the laps of the educational system.
I am afraid, however, that many educators I meet and associate with have little understanding of the American economic system or do not believe that they are in the mainstream of that system.
Perhaps it is because few teachers are required to take college courses in business administration or economics, etc.
Or perhaps it is because the educational system is a nonprofit government institution and the competitive economic nature of business is a system within which most teachers have never had to exist.
Or, it often seems to us, at least, that teachers fail to make the connection between business and industry making profits to pay the taxes which run the schools and pay teachers' salaries in every city and town in the U.S.

F. What Business and Education Need to Do Together

This is where the electric industry can help. In fact, our Company and many other investor-owned utilities have established an educational service program to assist the educational system in better understanding the technical and economic factors of our business.
Although we may be beset by energy problems, our modern society has increased our perceptions of those problems.
Technology has brought to the American public information in such breadth and detail that today's students have the abundance of information formerly reserved for the scholar of yore.[5]
We should not forget, however, that like the grade school graduate facing high school, many of our current problems result from our accomplishments of the past.
Indeed, when compared to most of the rest of the world, our past accomplishments have provided this time for contemplation of our problems and for a reassessment of our society.

However, even the U.S. cannot afford to pause indefinitely during this decade of transition.
The solution to today's problems is not to return to the problems of the past. It is rather a return to the progress of the past and using technology to overcome today's problems and move on to the problems of the future.
Few Americans recognize the role that abundant, low-cost energy has played in their choice of life-styles.
An education is as intrinsic to human existence as energy is essential to human progress. Without them, our perception and our enjoyment of the world would be greatly restricted. Both are the cornerstones of personal and economic growth necessary to vitalize today's generations and to ensure a solid base for the next one.[6]

Education is succeeding.
Today, people look at a degree as a process not just an objective.
They are realizing that education has a continuous and growing productive value, not just a one-time door opener.
The utility industry must try to make people see that our product, electricity, can not be taken for granted — that its real economic value is substantially greater than its historical price; and, ultimately, that it is the key to the comfort, productivity, and progress of our modern society.
So, from a self-interest point of view, energy education is needed so that the energy industry may, over the long run, continue to provide the products and services customers need and want.

The improved knowledge about energy; the improved understanding of the complex relationships within the economy, environment, society, and technology; and informed decision-making by students, teachers, and adults are needed if we are to provide secure supplies and readily useable energy now in this transitional decade and beyond the year 2000.
Besides knowing the previously mentioned factors about energy, students and adults need to develop skills in the application of these factors and the determination of their values to arrive at decisions regarding the energy trade-offs that are necessary.
The tools necessary to do the job can be developed through cooperative efforts of the educational system and the business world!

As I am sure you are only too painfully aware, educators of today have been overwhelmed with social responsibilities. Society in the 1960s and 1970s decided that teachers should no longer concentrate on the basic "3 Rs". The society saddled you with the concepts of "progressive education". Consequently, we have overwhelmed the schools with responsibility for education to reduce cavities; education to increase understanding of reproductive organs and contraceptive techniques, education to reduce drag addiction; education to increase skills in appreciation of aesthetics.
We have overwhelmed you. How much time do you have to spend on energy education?
I know that in Oregon, at least, several school districts have found it important enough to mandate. And, indeed, our State Department of Education is considering mandating energy education statewide.

So I know there is a need for energy education. For one thing, I know that the average textbooks you use are at least 5 years old and probably older. Therefore, whatever information they contain — and this is extremely crucial to the fast-changing world of energy statistics — may be 7-9 years old. Textbooks copyrighted in 1970 would contain nothing about the OPEC Oil Embargo, shortages of oil and natural gas, issues caused by National Environmental Protection Act, the Clean Air Act, the Federal Coal Strip Mining Act, issues over the use of uranium, etc.
Also, we know about the shortage causes great difficulties for schools to purchase new textbooks, A-V equipment and materials, library reference and resource materials on energy, curriculum guides and study guides on energy education, subscriptions to magazines and periodicals that contain timely and accurate energy statistics, etc.
We suffer from the same financial constraints you do — maybe more so.
But we are determined that it is in our best interest to operate as efficiently and economically as possible in order to provide as much material and cooperation to explain our business to the American public as we can.

In fact, we are bound by law to operate as economically as possible. Our charter to operate as a business, granted by the State of Oregon, has basically two provisions — that we must provide all the electricity that all the 1,200,000 people in our service area demand at any one time, and at the cheapest possible cost!
I doubt that there are very many other businesses or educational systems that operate under such a mandate.

And so to improve the energy literacy of today's students and teachers, we are willing to embark upon major programs such as EME, which I described previously.
We are willing to provide personnel to guide tours through our facilities to make real, for students, some of the abstract concepts they study in the classroom.
We are willing to provide resource materials which provide accurate and timely statistics regarding the function and operations of our industry.
We are willing to provide film, other A-V materials, teaching kits, etc., through our National Trade Association, EEI — that will fill some of the existing void for such materials.
We are willing to provide speakers for classroom programs on topics related to our industry.
We are willing to encourage and motivate our employees to participate in community orgranizations, such as Scouts, 4-H, Junior Achievement, church-related youth groups, etc.
Many of us are willing to have you, the educational experts, review or help prepare our materials, advise us on our programs, etc., by employing you as energy education advisory committees. Business today fully realizes its responsibility not to use the education system for "propaganda" or "corporate image" purposes, but realizes that teachers will only be confident in using the educational services we offer if these materials and services are educationally sound.

There are some 145 investor-owned utilities in the U.S. with an educational services program.
It may surprise you to know that in many cases the people responsible for these programs are former educators.
I offer this observation as evidence that our industry recognizes that propaganda, in any form, is abhorrent in the classroom and we from industry must adopt as a cardinal principle that material produced by us must be educationally sound.
We, therefore, are not interested in indoctrinating anybody to our point of view, but we interested in seeing energy educational materials are as accurate, objective, and balanced as possible in an imperfect world.
Students do not have to advocate our views, but we just hope that they will come to understand our views.

The EEI Educational Services Committee has developed six goals to achieve in its cooperative efforts with the educational system. I have appended goals to this paper for your information.
In addition, the committee has established suggested guidelines for production of industry educational materials that any company can use in preparing materials for students and teachers.
These are appended to my paper for your information.
It is hoped that these goals and guidelines will assist in making the materials we produce acceptable to educators.
Walt Purdy, staff member responsible for EEI educational materials and programs, happened to be a high school principal in Michigan for some 25 years before his employment with EEI. This fact should be considered by educators as a sincere desire on the part of the industry to produce high-quality educational materials.

III. CONCLUSION

Supreme Court Justice William O. Douglas once wrote that, "the public school is the true melting pot and the public school teacher the leading architect of the new America." Our society is becoming increasingly participatory — more people want to take part in more decisions. Universal education has never been more important or more needed or — in a time of shifting values — more difficult to obtain.
During this decade of the '80s, we need to be sure our vision and our programs of service to education are sufficiently broad.
We continue to need quality employees educated by you — both technical and nontechnical, managerial and nonmanagerial.
We will continue to need educated customers.
And, we will continue to need an understanding electorate — including the political and intellectual leadership groups especially.
I think it is appropriate for us, in concert with educators, to reexamine the ways we can be of best service to education, to society, and therefore, to our customers in the years ahead.

APPENDIX I
PGE Educational Services Program

PGE responds to requests from teachers for programs in their classrooms. Topics for such programs may include basic generation and distribution of electricity, electrical safety, careers in the electric utility industry, Pacific Northwest electric generation resources, conservation, and orientation to field trips to Company projects. Such programs may include the use of films, slides, videotapes, exhibits, and displays.

PGE also provides tours of Company projects upon request. School tours may be conducted of hydroelectric dams, combustion turbine plants, a solar demonstration home, the System Control Center, or certain areas of the Willamette Center complex.

PGE maintains a free-loan film library from which teachers may borrow films for their classes. Currently, more than 30 titles are included in the Film Library.

The Company receives numerous requests from teachers planning to teach units on energy or from students writing reports on energy. Therefore, each year, PGE sends packets of general energy informational materials to school libraries or media centers in our service area.

The Company has also developed bulletin board materials for teachers' use on topics of conservation and electrical safety.

In response to teacher requests, the department has developed educational materials on specific topics, such as conservation, consumer education, careers, and others.

PGE sponsors the *Screen News Digest*, a current events film program. Each month of the school year, a different film on a vital current events topic is distributed to schools in the Company's service area.

The Company also sponsors the EEI Library Grant Program for 20 high school libraries in our service area. Current information on energy topics is sent to these libraries monthly on a national level from EEI.

PGE sponsors the Energy and Man's Environment (EME) program in our service area. EME has become a nationally recognized program of excellence in the field of energy education. EME is a program of energy curriculum materials development, conferences, and teacher workshops on energy education.

The Company has developed or purchased various educational displays and exhibits for schools to use for special occasions. Such exhibits may be used for a science fair or for Energy Day (or Week), Safety Day (or Week), Career Day, or Conservation Day (or Week) activities. These are also used for exhibiting at professional educational conferences, such as National Science Teachers Association (NSTA), National Council for Social Studies (NCSS), Oregon Education Association (OEA), Oregon Science Teachers Association (OSTA), etc.

PGE also participates in and sponsors such youth service activities as Explorer Scouts, Junior Achievement Project Business, 4-H, and others.

The Educational Services Supervisor participates in local, state, regional, and national energy education organizations. These include the Institute for Public Affairs Research (IPAR), Energy and Man's Environment (EME), and NELPA and EEI educational services committees, to name a few.

APPENDIX II
Goals of the Edison Electric Institute Educational Services Committee

1. To assist in establishing the electric utility industry as a reliable, responsive source of educationally sound classroom materials pertaining to various aspects of electric energy.

2. To actively promote and encourage cooperation and trust between individual member companies and educators in the development and dissemination of energy-related educational materials.

3. To promote understanding of the American free enterprise system among students.

4. To develop, in cooperation with members of the educaitonal community, programs and services relating to energy education for provision to member companies.

5. To seek participation in the development of energy curriculum by national and state educational organizations.

6. To seek active participation in educational forums to spotlight the work of the industry in energy education.

APPENDIX III
Edison Electric Institute Educational Services Committee

Guidelines for the Production, Distribution, and Use of School Materials, Programs, and Activities

In order that programs, materials, and activities produced for schools by community agencies be of the highest quality and maximum effectiveness, we endorse the following guidelines and further urge their adoption by all EEI member companies.

General Considerations

Worthwhile and effective energy education programs, activities and materials:

— have clearly stated goals and objectives stated in terms of expected student behavior
— treat controversial issues fairly and honestly and do not advocate any one particular point of view
— are concerned with helping students learn *how* to think, not *what* to think
— clearly identify opinion and company or agency policy if included
— are not used to sell products, agency policies or political points of view
— are sensitive to human values and avoid racial, sexual, occupational, regional, handicapped and other stereotypes

Design and Production of Materials

Better, more usable educational programs and materials result when:
— clearly stated and measurable goals and objectives are establsihed early in the development process
— those who will be using the materials — students, teachers, administrators — are involved in the process
— they are designed to mesh with ongoing educational activities and are compatible with adopted courses of study and state frameworks
— provision is made for student-teacher creativity and innovation
— they are targeted to specific grade levels and subject matter areas
— consideration is given to the physical design and package of materials so that they are attractive and convenient to use

Program Implementation

An effective implementation plan is needed if educational programs and materials are to be of maxiumum effectiveness. A good implementation plan:

— makes use of the services available through professional associations, teacher training institutions, staff development centers, county offices of education, the State Department of Education and othe related agencies
— includes provision for the instruction for those who will be using the materials

Evaluation

The value of all programs and materials is determined by their effectiveness with students. Evaluation is therefore a key program element and should provide for:

— field testing and evaluation of all programs and materials in terms of stated goals and objectives by students and teachers prior to widescale implementation
— provision for continuous feedback and modification as needed once a program is underway
— test instruments and evaluation suggestions for classroom use

FOOTNOTES

[1] Bertram Wolfe, General Electric Company, "Technology an the Welfare of Mankind," presented at the American Nuclear Society Winter Meeting, San Francisco, California, November 12, 1979.

[2] Dr. William H. Dresher, Dean, College of Mines, University of Arizona, and Director, State of Arizona, Bureau of Geology and Mineral Technology, "Pressure Points — Conflict Between Federal Policies and National Energy Needs," presented at the Public Utilities Communications Association, Region 6 Workshop/Conference, Phoenix, Arizona, July 13, 1978.

[3] Dr. John H. Francis, Vice President, Florida Power & Light Company, "Utilities in the Classroom: Why Not?", presented at the Atomic Industrial Forum Conference, Houston, Texas, September 12, 1978.

[4] Dr. Richard Scheetz, Manager, Educational Services, Edison Electric Institute (retired), "Energy Education and the Schools," presented at the Education Confronts the Energy Dilemma National Conference, Washington, D.C., June 22, 1977.

[5] Bill Perkins, Director, Committee for Energy Awareness, "The Dying of the Light," St. Louis, Missouri, June 18, 1980.

[6] Paul D. Ziemer, President and Chief Executive Officer, Wisconson Public Service Corporation, "EEI's Communications Policy and the Educational Community," presented at the EEI Second National Conference of Electric Utility Educators, Dallas, Texas, June 13, 1979.

1.4

EDUCATION IN ALTERNATIVE ENERGY SOURCES

E.F. Curd., M. Phil, C. Eng.M.Inst.E., MCIBS.

Education in Energy Topics:

From numerous visits to schools, involving discussions with teachers and students, and from introductory lectures to students in Higher National and Degree Courses at Liverpool Polytechnic, it has become evident to the author in all cases, that the very important topic of the world's energy resources, and the methods of energy generation are by no means receiving an adequate and sound treatment in the school curriculum. In general it can be said, that many teachers are lacking in information, hence the students are ignorant and misinformed on the elements of all energy matters.
The various science disciplines, such as physics, chemistry, and biology all have different approaches to energy. Examples being physics, relating energy to potential and kinetic energy, while the biologist relates energy to photo synthysis, and metabolism. One cannot dispute that these are important subjects in their respective fields, and as such are rightly an essential part of any school curriculum. What is lacking however is an introduction to the basis of "Energy Technology" in an unbiased manner.
The study should include, fossil fuels and their burning with the resulting energy production, this should be related to the replenishable sources of energy, and their respective merits.

It is only when these fundamentals are understood that the student can be said to be obtaining a fair rational education. I have used the word 'fair' as in many discussions it was evident that a large proportion of the ideas imparted, either by teachers, visiting lecturers or by the popular press or media are unrealistic and biased condemning out of hand the need for nuclear power, or any research in this field. The argument being, it is too dangerous to use. The general postulations are that our only salvation from the energy gap is by the use of aerogenerators, wave power, geothermal, and solar, etc. This approach cannot be called education.
It must be realized that all sources have a role to play, and as such, each case must be looked at in a scientific reality, and not in a brain washing, or unscientific manner.

As the world energy scene becomes more uncertain, and the uneven distribution of energy throughout the world become more critical, we will be unable to escape the political and economical troubles created by the ensuring demands on the availability of fossil fuels, which we rely on for our standard of living. Education in this field will assist us in overcoming many of the problems of the future.
There are no shortages of possibilities of alternative energy sources in any given area, and we should not rely only on one form of energy. The economics of using the various forms must however be considered.
Only when students understand the basis of energy production, will the conservation programmes on which Western Governments are spending vast sums of money on, will become meaningful. With understanding indiscriminate energy use must become a thing of the past, resulting in an extension in the life of fossil fuels and savings in the balance of payments.
With adequate tutoring in this field, the students may be inspired to continue studies in the energy field by becoming engineers.

We will now consider a suggested approach to teaching energy subjects. This being based on the authors paper given at the ICASE Conference at Monte Carlo 1981.

Teaching Energy Subjects:

On introducing energy subjects in the school curriculum, an organising committee should be formed with a variety of expertise to formulate the course. These studies must be inter-disciplinery, and will require a broadening of the education of many teachers. Being a new topic considerable time will have to be spent in corse preparation, and in obtaining essential data. It will be appreciated that unlike many conventional subjects, energy topics are in a complete state of continual flux, requiring constant updating.

A possibility exists that knowledge will be passed on to the student in the way it was acquired, this is unsatisfactory. To overcome these problems, consideration should be made in approaching the EEC to finance common in-course teacher training in the whole range of alternative energy topics.
Industry and the public utilities can also assist, by opening their doors to teacher and student, and introduce them to the present methods of energy generation.

Courses should be designed that the students appreciate the following:

i) Fossil fuels are a finite source
ii) The political and economic factors involved in energy generation
iii) The various alternative energy forms available
iv) The limitations of these possible sources
v) The make up of the design team and the role of the engineer

The nature and the degree to which these elements are covered will obviously depend on the students age and the teachers training. In covering these items, the following should be considered: topic relevence, meaning and feasibility.
The scope of the subjects to give a basic understanding is wide and should include in balanced proportion the following:

TOPIC
i) Origins & Nature of Fossil Fuels
ii) Methods of Heat and Power Generation
iii) Energy Economics
iv) Socio-Political Implications

SUBJECTS TO BE STUDIED
Geology, Geography, Physics, Chemistry, etc.

Heat Transfer, Combustion, Thermodynamics, Mechanics, Fluid-Mechanics, Electrical Engineering, Maths, etc.

Pricing Policies, Evaluation, Energy Costs (Significance), Energy Accounting.

Energy Politics, International & Domestic Implications, Relationship between the State and the Energy Market, Transport Problems.

The wide range of topics that can be considered in energy studies is shown in Figure 1. For the purpose of this conference we will only consider solar energy as this subject lends itself to a whole range of simple and cheap experiments. The other subjects however must not be ignored and similar syllabi are available.

Teaching Syllabus:

Before attempting to cover the numerous forms of alternative energy available, it is essential to consider a basic core study including:—

1) Origin and source of solid, liquid and gaseous fuels
2) Energy science (Energy Conversion)
3) The Energy Gap
4) The role of alternative energy sources.

Complete syllabi for the above four items are not included due to space reasons, it is hoped however, the following brief syllabi will provide a suitable approach.

1) Origin & Source of Solid, Liquid & Gaseous Fuels:
(For space reasons only liquid fuels will be considered)
Aim: To enable the student to appreciate the problems associated in obtaining and burnng these fuels, and to understand that fossils fuels are a finine resource.

Definition: Liquid fuel can be conveniently divided into the following classfications:
1) Light oil or spirits (used in internal combustion and jet engines).
2) Heavy oils (used for burning in heat generating plant)

Subjects that can be studied in this topic:
1) Geology (formation of oil deposits)
2) Geography (location of these deposits)
3) Engineering (methods of detection and recovery)
4) Fuel technology (methods of storing, burning and testing)
5) The petro - chemical industry (products obtained)
6) Pollution (air, land and water)
7) Political and economic implications

2. Energy Science (Energy Conversion)

Aim: To introduce the students to the basic ideas of burning fuels, pollution problems, heat transfer and energy conversion methods. During the course it is essential that the student appreciates the implications of the 1st & 2nd. Law of Thermodynamics and the possible efficiency of plant in practice.

3. The Energy Gap:

Aim: To understand the relationship between the limited supply of fossil fuels, and the general trend per capita for increasing fuel consumption, and the resulting energy gap, and how this gap can be filled by alternative sources. It is essential at this stage to emphasise, many years are necessary to develop new schemes from initial stage to the completed project.

Origin: Derived from animal and vegetable debris that have accumulated over millions of years, in sea basins or estuaries, and buried there by sand and silt. The decomposition of these debris may have taken place by:
1) Anaeobic bacteris under reducing conditions or
2) Heat generated by earth movement or depth of burial

The final result being a dark viscous product of the following approximate composition: Carbon 80-89%, Hydrogen 12-14%, Nitrogen 0.3-1%, Sulphur 0.3-3%, Oxygen 2.0-3%.

Oil may also be produced by cataytic processes carried out on coal.

World Recoverable Oil Reserves: Uncertainty is always associated with the estimation of the life of fossil fuels due to many factors (vis) political, geological, economical, industrial, etc.
Estimates range from 18-40 years.
Shale oil and tar oil sands will extend these estimates, however, recovery by these methods is expensive.
It is of interest to note that in 1744 B. Franklin invented a fire place to conserve fuel for indentical reasons as we are considering today.

Having considered the previous three topics, a study of the various alternative energy schemes will now become meaningful.

4. Role of Alternative Energy Sources:

Aim: To enable the student to appreciate the various forms of alternative energy, and self sufficiency available, and the limitation, advantages and disadvantages of each in filling the energy gap.

*Typical Topics to be Covered:*Solar, Wind, Wave, Tidal, OTEC, Geothermal, Hydro-Electric Schemes, Hydrogen Energy, Heat Pumps.

At this conference only solar-energy is considered, a syllabus for this is given in Appendix 1.

APPENDIX 1.

Teaching Syllabus: "Alternative Energy Sources"

Subject: Solar Energy

Aim: This syllabus is designed to enable the student to grasp the fundamental theory necessary to appreciate solar energy utilisation and applications covering:
i) The star that controls our existance.
ii) Its effects on the world climate.
iii) How its radiant energy can be utilized to a greater extent than at present.
iv) The implications of solar energy usage on a national and world front, and its effect on the energy gap.

The subject can be conveniently divided into the following groups:
i) Thermal conversion.
ii) Electrial conversion.
iii) Chemical conversion.

Each of these can be further subdivided. In the case of thermal conversion, to cover the factors related to flat plate collectors, parabolic collectors, direct and indirect passive buildings, etc.

For this syllabus only flat plat collectors will be considered. However many of the items covered are common to the other topics. If necessary the three conversion methods could be united to produce a broader syllabus.

A.1 Nature of the Sun

1.1 Explains the reactions assumed to take place in the sun.
1.2 Knows the mean distance of the sun from the earth.
1.3 Knows the mean diameter of the sun.
1.4 Knows the mean surface temperature of the sun.
1.5 Knows the power output of the sun.
1.6 Defines extraterrestial solar energy intensity.
1.7 Knows the distribution of solar energy intensity.
1.8 Defines the term solar constant.
1.9 Understands the pat of the earth round the sun.
1.10 Knows how radiation passes from the sun to the earth.

B. 2 Nature of the Earths Climate

2.1 Understands the basic factors that effect the earths climate.
2.2 Knows the general patterns of winds (local and world wide).
2.3 Understands the term diurnal temperature variations.
2.4 Describes how meteorological measurements are made.
2.5 Appreciates surface solar energy intensity and distribution.
2.6 Defines direct, diffuse and ground radiation.
2.7 Defines air mass.
2.8 Defines Albedo.
2.9 Define the term 'greenhouse' effect.
2.10 Defines insolation.
2.11 Defines turbidity.
2.12 Knows how solar intensity varies with solar altitude, angle and station height.

C.3 Solar Geometry
3.1 Defines declination angle.
3.2 Defines hour angle.
3.3 Defines altitude angle.
3.4 Defines azimuth angle.
3.5 Defines incident angle.
3.6 Defines latitude angle.
3.7 Defines orientation angle.
3.8 Defines orientation angle.
3.9 Derives solar and surface angle.
3.10 Calculates intensity of solar radiation on horizontal and vertical surfaces.
3.11 Constructs a sun chart.

D.4 Heat Transfer
4.1 Defines temperature and knows the fixed points on the thermometer scale.
4.2 Differentiates between temperature and heat.
4.3 Defines conduction and gives examples.
4.4 Knows the Fourier rate equation for conduction.
4.5 Defines conductivity and knows the factors that effect it.
4.6 Defines resistance and surface resistance.
4.7 Defines thermal transmittance.
4.8 Calculates rate of heat flow through a composite structure.
4.9 Defines thermal radiation and gives examples.
4.10 Knows the nature of thermal radiation.
4.11 Defines reflectivity, absorptivity and transmissivity.
4.12 Defines total emissive power.
4.13 Defines a black and grey body.
4.14 Defines Monochromatic Power.
4.15 Knows the Stefan — Boltzmann law.
4.16 Describes how radiant heat transfer takes place between black bokies.
4.17 Solves simple radiation problems using (4.15)
4.18 Defines natural and forced convection and gives examples of each
4.19 Applies simple formula in each case of (4.18) to solve problems.
4.20 Defines specific heat capacity.
4.21 Defines mass flow rate.
4.22 Solves problems associated with mass, specific heat and temperature difference.
4.23 Differentiates between latent and sensible heat
4.24 Defines enthalpy.
4.25 Defines thermal expansion.
4.26 Appreciates importance of thermal expansion.
4.27 Solves simple problems involving linear expansion.

E.5 Panel Collecting Devices

5.1 Understands the construction of a plate collector.
5.2 Knows the effect of surface colour.
5.3 Knows the difference between the various heat transfer fluids used in plate collectors.
5.4 Understands the relationship between the flow rate and water temperature on a panel.
5.5 Appreciates the positioning of a panel and its optimum inclination for summer and winter use.
5.6 Knows the difference between a thermo-syphonic systems and accelerated systems.
5.7 From local meterological data, calculate the collector size for a given duty.
5.8 Determines the efficiency of a panel.
5.9 Describes the effect of nocturnal radiation.
5.10 Describes the difference between a water storage and rock bed storage system.
5.11 Calculates the storage required for a given duty.
5.12 Describes the control necessary.
5.13 Describes typical applications of plate collectors.
5.14 Knows how plate collectors can be included in building design.
5.15 Understands how corrosion attacks collectors.

F.6 Design Team

6.1 Knows the role of the engineer.
6.2 Knows the role of the structural engineer.
6.3 Knows the rule of the architect.
6.4 Knows the role of the quantity surveyor.
6.5 Knows the role of the builder.
6.6 Knows the role of the meterologist.

G.7 Owning & Operating Costs

7.1 Knows the cost of energy input to manufacture a panel.
7.2 Compare (7.1) with the useful energy output over the life of the panel.
7.3 Knows the cost of installing & operating a panel.

7.4 Relates the cost of energy achieved by solar collector with conventional fossil fuels.
7.5 Determine economic viability of the solar plate collector in your district.
7.6 Comment on (7.5) with projected fossil fuel increases over the next 10 years.
7.7 Relates national savings on fossil fuels should solar application become viable.

Note: This subject lends itself to numerous easy and cheap experimental topics.

1.5

ENERGY EDUCATION ASSESSMENT
K-12 Maine Teachers

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For several years, educators interested in teaching about energy have been contacting the Maine State Office of Energy Resources (OER) and the Maine State Department of Educational and Cultural Services (DECS) for assistance. Several groups in addition to the OER and DECS, have responded to the energy education needs of Maine teachers in a variety of ways. Although considerable effort had already occurred in relation to assisting teachers, this effort was not effectively coordinated. Inadvertently, approaches to energy education varied and duplication of effort was inevitable. Requests to the OER and DECS as well as other groups, for information have been increasing steadily. The diversity and numbers of requests has resulted in the somewhat haphazard manner in which energy education was addressed in Maine.

It became apparent to the OER and DECS that a state-wide, comprehensive energy education program should be initiated. This approach was considered to be far more efficient than to deal with energy education on a case by case basis.
In order to develop a program which would be based on the actual, expressed needs of Maine teachers, a Task Force was formed. This Task Force comprised of educational professionals was formed to identify and document energy and education-related activities, resources and opportunities which exist in the state today; to conduct a state-wide needs assessment of Maine teachers; and to make recommendations based upon the results of the survey to OER and DECS to meet the identified needs.

The decision to conduct an energy education needs assessment of Maine teachers was made in the fall of 1979. It was felt that surveying the teachers to determine their energy education needs would provide OER with specific direction in its school energy education efforts. It was felt that gaining teacher input would be positive for three reasons. First, it would provide valuable data which would be useful information for educators interested in developing energy education materials. Secondly, it would ensure that any materials developed as a result of the survey would be based upon the expressed needs of teachers. And finally, teachers would feel more ownership in materials which were based upon teacher input, and thus be more apt to use those materials.
Once the decision was made to conduct an energy education needs assessment of Maine teachers, a state-wide Energy Education Task Force (EETF) was formulated. Since the OER and DECS are only two of several agencies in Maine concerned with energy education, groups such as Maine Audubon, the University of Maine at Orono, and other groups and individuals were invited to join our efforts. The first and foremost concern was that this Task Force be sponsored jointly by the Director of the OER and the Commissioner of DECS. It was a highest priority to involve individuals interested in energy education. It was felt that a successful, quality energy education program could best be developed as the result of cooperative efforts between the State offices of energy and education as well as other interested agencies.

The primary goals of the Task Force were as follows: to identify and document energy and education related activities, resources and opportunities which already exist in the State of maine; to conduct and document a needs assessment to determine the energy education needs of Maine students and teachers; and to develop a strategy and make recommendations to the OER and DECS, making optimum use of existing resources to meet identified needs.

It was decided the survey should be distributed directly through teachers and principals by contacting three different groups: Title IV schools, minigrants recipients and geographically selected schools. A different letter was sent to each of the three groups.

Title IV C is a federal grants program through the U.S. Department of Education which provides funding to schools interested in developing innovative curriculum projects. This group was chosen to be surveyed based upon their apparent openness to new ideas. The Title IV C Group does not necessarily represent teachers who are involved in energy education projects. Only one school out of thirty-four in this group has been involved in an energy education project. Several Title IV C school districts were contacted and asked to participate in the survey. The school administrator was responsible for distribution of the survey to all teachers (K-12, all subject areas) in his/her district.

The OER sponsors a small grants program for teachers who wish to develop energy activities for their students. All teachers who have participated in this program were contacted and asked to distribute five (5) questionnaires to other teachers (K-12, all subject areas) in their school system. The minigrants teacher could choose to respond in which case four other teachers responses were sought. In general, it was felt that this group would be favorably disposed toward energy education since the effort to distribute the questionnaire within the school was initiated by a known energy educator. However, it was requested that the surveys be distributed as randomly as possible.

After the first two groups were identified, the geographic location of those schools was plotted on a map of Maine. It was then apparent that several geographic areas were not represented in our survey. It also appeared that there was a disproportionate balance in the representation from rural versus urban schools. Superintendents of the school districts in locations missing from our survey were randomly selected and invited to participate in the survey. It was their responsibility to distribute the survey to teachers (K-12, all subject areas) in their districts.

For a population of 10,000 (the approximate number of teachers in Maine) the sample should yield a minimum of 370 responses for the study to be statistically valid and within reasonable confidence intervals (1). It was expected that overall response of about twenty percent would be received.

A total of 1,761 questionnaires were sent to fifty-two schools and school districts throughout the State. The survey distribution and response are found in Table 1.

Table I
Survey Distribution and Return Rates

Group		#Surveys Dist.	#Surveys Rtn.	% Survey Rtn.
I. Title IV C Schools		929	339	36%
II. Minigrants School		195	60	31%
III. Geographically Selected		637	119	18%
	TOTAL:	1761	518	29%

Considering the limited time frame for distribution and return of the survey, the overall return rate of 29% was considered by the EETF to be an excellent response.

A further breakdown of those surveyed indicated a reasonable proportioned response from elementary, junior high and high school teachers in Table II.

Table II
Number and Percent of Responses for Each Group

Grade Level Surveyed	IV C	MG	Sel	Total
K-6	129 (62%)	27 (12%)	54	210 (40.5%)
7-8	82 (76%)	11 (10%)	16	109 (21%)
9-12	125 (68%)	26 (12%)	38	189 (36.5%)

Question #1 — What energy topics should be taught?: All topics mentioned in the survey were ranked as important for teachers to infuse into their teaching. The range was from "energy effects on careers" receiving a media rating of 3.345 to "energy conservation" with a high of 4.704 on a 5 point scale.

Question #2 — At what grade level do you feel the following energy topics should be taught? (There were ten choices to the question.): The data was looked at in terms of what percentage of the respondents indicated their preference for teaching each of the five energy topics at a given grade level. The percentage of responses ranged from 0% to 47.1%.

a. "Energy concepts." Thirty-two percent of the teachers surveyed thought that energy concepts should be taught K-12. This percentage is twice the response for any of the other ninth grade level options. The second highest response was 15.5% for grade level 3-12 while 14% felt it should be taught in grades K-2. Therefore the EETC concludes that energy concepts can and should be taught at all grade levels with a focus in elementary schools.

b. "Energy conservation." Almost half (47.1%) of the teachers surveyed thought energy conservation should be taught at all grade levels. The next two highest percentages went for grade levels K-2 (13.5%) and 3-5 (14.1%) indicating that teaching about conservation must begin in the elementary grades and focus there.

c. "Alternative energies." The grade level focus for teaching about alternative energy which received the most support (27.2%) was 6-12. Support from 17.1% was given to grade level 3-12, and a close third was K-12 with 16.8%. This information indicates that, while many of the respondents felt that alternative energy instruction can be taught at all grade levels, it should be focused in the secondary grades.

d. "Energy problems and issues." The greatest percent of teachers felt that "energy problems and issues" should be taught in the upper grades, 6-12 (26.7%). Of the upper grades, more felt that it should be focused on the high school, 9-12 (19.5%), than in junior high school, 7-8 (12.8%). A significant number also felt that "problems and issues" could be taught K-12 (15.7%), although only 2.13% felt it should be focused on in K-2, whereas a total of 22% felt it should be taught in either grades 3-5 or 3-12. We conclude from these figures that while many teachers feel that energy problems and issues should begin to be covered in third grade that the primary focus should be grades 6-12.

e. "Energy effects on careers." Clearly the respondents felt that the place for studying energy as it relates to career education was in high school. A large percentage (44.9%), indicated that the focus should be grades 9-12. However a significant number also felt that it could begin in junior high school (37.7% for 7-8, 6-12 combined).

Question #3 — What is the energy competencies of students?: The respondents indicated that students' knowledge of all of the energy topics areas except "careers" (1.693) to "concepts" (2.629). While "energy conservation" was ranked as the most important topic to be teaching, the students knowledge of this concept was ranged as good (3.045). It was the conclustion of the EETF that the teachers feel that, although there is room for improvement, their students understand conservation better relative to the other topics mentioned.

Question #4 — How important is it for students to be aware of social aspects of energy?: This question supplements question #3 by emphasizing the importance teachers place on having their students understand how their own personal values and lifestyles, and the decisions they make, ultimately affect overall energy use and availability. The range from 3.861 for "future job choices will be affected by energy availability" to 4.554 for "one's life style affects energy consumption" reinforce the need for teaching both values clarification and energy conservation.

Question #5 — How would you recommend that energy be taught in the curriculum? could be answered with a yes or no and the choices were: (1) "Taught as a separate course" or (2) "Integrated into various subject areas." Some respondents checked both choices with a "yes." Although twice as many respondents though it should be integrated rather than taught separately, a sizeable portion felt that it was viable to teach it as a separate course, particularly in the upper grades. An analysis of this data substantiates the idea that energy is an interdisciplinary subject that should by no means be restricted to the science classroom. If one compares the responses to question #1 from teachers representing all subject areas (science, special education, math, social studies, art, physical education, etc.) it becomes clear that there is a strong interest in energy education for all subject areas.

Question #6 — What resources do you need to teach energy?: media resources are clearly needed by Maine's teachers. This question asked about classroom resources that teachers need to assist them in their energy education efforts. "Movies" were ranked as most important (4.214) "filmstrips" (4.034) and "slides" (4.000) followed close behind. Ranked lowest were "textbooks for students" (3.081).

Question #7 — What are the most important teacher resouces needed? In response to the need for "teacher resources" there was not a significant variation to provide the EETF with a clear delineation of priorities for developing resources. Rather, there was a strong interest in many teacher resources ranging from "workshop/in-service training" (3.881) to "background information" (4.054) and "community resources" (4.059). These figures indicate a real desire on the part of teachers to become knowledgeable about energy.

Question #8 — What resources have been helpful?: As a result of tabulating the responses generically, it was found that four types of resources received considerably more support than the others listed by the teachers: *Media:* This includes primarily newspapers, TV, films, slides, and journals. *Instruction:* This includes in-service workshop, teacher training institutes, university level courses and other educational programs. *Agencies:* This includes government and private, non-profit agencies such as Office of Energy Resources (OER), Maine Audubon Society, Community Assistance Programs, Co-operative Extension Programs, U.S. Department of Energy (USDOE). *Materials:* This includes miscellaneous materials suppleid by USDOE, OER, National Science Teachers Association, Maine Audubon and local utilities.

According to the survey, student knowledge of energy topics were less than satisfactory. Since teachers expressed a strong interest and desire to be teaching about energy, the EETF concluded there exists a real need for a school energy education program.

The following are the recommendations hereby submitted by the EETF for the development of such a program.
1. The Office of Energy Resources (OER), the Department of Educational and Cultural Services (DECS) and the University of Maine-Orono (UMO) should establish a comprehensive school energy education program for the State of Maine.
2. A Planning Committee should be formed, jointly chaired by OER, DECS and UMO, for the purpose of developing this State-wide energy education program.
3. The Planning Committee should also include and represent school administrators, teachers, educational groups and other interested individuals and organization with close relation to educational programs in our schools.
4. The specific tasks of this planning committee should include the following:
a. Evaluation of existing curriculum resources available in energy education.
b. Develop a framework for Maine schools K-12 curriculum into which energy concepts may be infused.
c. Adopt and or develop an interdisciplinary, K-12 energy education curriculum for Maine's schools.
5. The survey data of this needs assessment should be used as guidelines for the selection, adaptation or development of curriculum materials for Maine's schools.
6. Teacher pre- and in-service training should be a primary focus for the resultant energy education program.
7. Efforts to acquire funding for developing or adapting curriculum materials should begin immediately.

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1.6

A CURRICULUM STRATEGY IN ENERGY EDUCATION FOR THE SECONDARY SCHOOL

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A Curriculum Strategy in Energy Education
for the Secondary School

Abstract

During the last twenty-five years numerous efforts have been made to effect curriculum changes in the science courses of the secondary schools. The first major effort was associated with the Sputnik era when considerable sums of money were made available through the National Science Foundation. Since the end of that era, and particularly during the past decade, we have witnessed numerous efforts to have such topics as ecology, sex, alcohol abuse, drugs, scientific creationism, environmental education, career education, and others taught in the science curriculum. Few efforts of this latter era have met with notable success for numerous reasons. The current topic of energy education is but another such topic.

There are ways in which energy education can be incorporated into all science courses with no great expenditure of time or money. These are (1) to teach science within a framework of a concept of that energy which is a natural and concomitant part of the science being taught; and (2) place emphasis on teaching for the transfer of what is learned about energy to everyday practical situations. This proposal is not offered as a panacea but as a natural and practiacl way to begin a program of energy education in secondary schools.

A quarter century ago the Russians launced the first man-made earth satelite, and a virtual wave of hysteria swept the nation. Something had to be done immediately in order for the United States to attain space superiority. In secondary schools the study of science and mathematics suddenly moved to the forefront at the expense of social studies and English. The National Science Foundation was created, and monies were appropriated for numerous purposes. The efforts which were undertaken to upgrade science instruction took two principle forms. One of these was to improve teacher competence in the subject matter of their teaching field. This was accomplished, primarily, through teachers education institutes which were funded for inservice science teachers. The second method resulted in what later became known as the national science curriculum revision movement. This culminated in such curricula as Chem-study chemistry, PSSC physics, BSCS biology, ESCP earth science, and numerous others. It should be noted that the once popular science fair owes its origin to this era of change in science and science education.

This period of activity lasted for more than a decade and resulted in many science programs, some instruction-oriented and others curriculum-oriented. Also, millions of dollars were appropriated for these science programs which involved thousands of teachers. This ambitious and expensive undertaking was conducted essentially for two purposes: (1) to upgrade science instruction in general, and (2) to have certain science topics or science-related topics taught in the science subjects of secondary schools.

Beginning with and lasting through the 1970's, science teachers were confronted with an array of new topics which various interest and pressure groups deemed to be of importance and which could be taught through the science curriculum. Ecology became important. We became pollution-conscious. These and other related concerns resulted in proposed environmental education programs. Ecology thus became an important phase of life science in grade seven, earth science in grade nine, and biology in grade ten. Other areas of concern were also included in the science curriculum, among them drug education, alcohol abuse, sex education, and career education. The latest topic to emerge is scientific creationism (whatever that is) to be taught on an equal basis with evolution in biology classes.

Regardless of what the nature of the topic may be, if it is to be incorporated into science subjects, three questions must be answered: (1) How does one get the topic into the curriculum of the schools? (2) What resources are available to teachers for teaching the topic? (3) How do you motivate teachers to teach a certain topic? The answers to all three of these questions are not only difficult, but the discovery of some answers usually necessitates the spending of considerable sums of money. This is why many proponents of having this or that topic taught through existing science courses have met with very little success. In addition, the syllabus of the typical teacher is still the adopted textbook. The content of textbooks changes very slowly and is subject to the whims and fancies of the authors and publishers as they view curriculum content needs.

What does all of this have to do with energy education? Viewed historically and in retrospect, the current topic of energy education is but one in a long list of studies advocated by many individuals and groups for inclusion in the science curriculum of the secondary schools.

As a supporter of energy education, I would like to offer the following proposal for initiating the study of energy education as an integral part of the science courses of secondary schools. This proposal does not require special institutes for teacher preparation nor the production of expensive instructional materials. It has two components. The first is one of a new orientation for the science teacher — that is, the use of a different frame of reference and emphais in the teaching of science. The second is one of placing more emphasis on the relevance of energy education to the students' everyday world.

In the matter of orientation, it is obvious that the subject of energy pervades all of science. To teach science is to teach energy. Without energy there is no science. For example, a typical course in physics consists of a study of five areas — mechanics, heat, light, sound, and electricity. Four of these areas are a study of a specific form of energy. But how many students, as well as teachers, view these as four separate topics to be studied rather than the study of four forms of energy?

One of the criticisms of the study of biology has been that too much emphasis is placed on the *what* of biology rather than the *how* of biology. Such areas of study as DNA, mitosis, and photosynthesis, are usually learned through memorization with the aid of charts and diagrams. But what is biology — the study of life, plant or animal — without energy? The basic unit of life itself, the cell, is a study in the production and use of energy. What is a plant or animal, other than a mass of cells working in unison within a framework of energy production and use. The source of all food, of all life, is the sun, a producer of the electromagnetic spectrum, a spectrum of energy from the process of nuclear fusion.

And what about chemistry? Chemistry is energy; energy is chemistry. Surely, there are basic definitions to be learned such as molar solutions, acids, bases, and salts. But these are the tools of communcation. Why should laboratory manuals, and teachers as well, instruct students to "heat the contents of a flask" w ıen they could more correctly tell students to "energize the contents of the flask."

Earth science — geology, meterology, and astronomy — are all a study of energy in action or the results of energy in action from the past.

I believe that the typical teachers of science know the subject matter of science. I also believe that teachers know the energy component of what is taught. The first step then in energy education should be a matter of change in the orientation of these science teachers. In teaching science, the teachers must relate the interdependence of the study of science to energy. They must teach science and energy in concert. They must inject the energy ingredient into cause and effect relationships, and they must emphasize the how of science rather than the what of science. One might ask how we ever arrived at the teaching of any science, be it physics, chemistry, biology, or other, in isolation to its essential energy component.

The second component in energy education in this proposal is one of relating the sciences and their energy constitutents to the practical world of reality and to the problems of energy which we face today. The psychologists call this the principle of transfer of learning. Research shows if you expect transfer to occur, you must teach for it. Teaching for transfer should be nothing new for good teachers. However teachers might be made more aware of how much they might accomplish in the realm of energy education if they gave more attention to the matter of transfer of learning. We can also take a cue from our metric education friends who have coined a very appropriate phrase, the resulting action of which is essential if we are to become a metric society. The phrase is "Think Metric." We need to "think energy," and science teachers should think energy in teaching science.

This proposal for an energy education program through the science courses of the secondary school is not a panacea. Instead it is recommended as a viable and inexpensive way to begin. As indicated previously, it is a matter of teaching for the understanding of science in conjunction with energy-related components and teaching for transfer at every opportunity.

By way of implementing this proposal, much of what is suggested here can be communicated to teachers by several already existing means, and with minimal or no expense. One of these is through appropriate articles published in the professional journals which are read by most dedicated science teachers. A second would be by communicating this concept of energy education to teachers through instructional supervisors at local and state levels. Another might be to have this concept of energy education appear as a program item at state and local meetings of science teachers. Finally, it could be a topic for inservice meetings of science teachers.

If we are serious about energy education through science instruction in secondary schools, the suggestions made here could be a practical and inexpensive way to begin. In the event that considerable sums of money and other resources should become available, additional avenues should be sought.

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INVITED 1.7
Energy Education: A View from the NSTA

John M. Fowler

Abstract

The National Science Teachers Association (NSTA) has been involved in energy education since 1974. In 1976, we began a curriculum effort — the Project for an Energy-Enriched Curriculum (PEEC) first with support from the Energy Research Development Administration (ERDA) and then from the Department of Energy (DOE). During these past five years, we have seen energy education grow strong in the grassroots. There are several national projects developing curriculum materials and many, many state and local groups producing their own. There have been three Practitioners Conferences on Energy Education, National Energy Education Day has been celebrated for two years in a row and in 1981 there will be, in addition to this International Conference on Energy Education, a National Conference on Energy Education in Detroit, Michigan on November 22nd.

1981 is a year of high visibility for energy education, but is also a year of problems. Since energy education is not a discipline, it does not have the cohesiveness of other educational efforts and, therefore, it does not have the cohesiveness of other educational efforts and, therefore, it does not have political clout commensurate with its importance. The change in administration has seen a change in federal policy toward energy education which is resulting in a ten-fold or more reduction in federal support. Whether and how energy education can survive these changes, the role of the private sector, and the questions of who will evalute materials, who will provide support for and run the necessary workshops, whether there be a network and clearinghouse, etc. are now all urgently awaiting answers. These changes and questions are discussed in the paper.

What remains unchanged is the fact that the nation is going through a momentous transition in its energy production and use and that the students who will direct and be affected by this transition are now in our schools. Energy education remains a most important priority for the nation's educators.

INVITED 1.8

Collaboration in Energy Education: Pitfalls and Promises

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Abstract

Collaboration in the planning and implementation stages of energy education initiatives is as important to the success of these programs and their incorporation into a given educational setting as interdisciplinary subject matter content is to the relevance of curriculum and resultant learning opportunities provided for students.

However, as energy education begins to receive greater focus in American schools and colleges, there is a compelling need for both theorists and practitioners to avoid over emphasizing the importance of interdisciplinary subject matter content while neglecting almost entirely the vital interactive processes of collaboration.

All too often the temptation to "do one's own thing" undermines well-intentioned efforts by educators who, in the rush to be on the cutting edge of change in education, fail to recognize that integrated and systemic planning require more than just a new array of zealous specialists, innovators, and reformers working in isolation or at best with minimal contact with others. The entire basis for this counter-productive behavior cannot be placed at the feet of educators alone, however; the lack of policy direction emanating from educational agencies and institutions as well as the Federal sector must be regarded equally as a contributing factor. Needless to say, some attempts at collaboration in energy-related education undertakings among the various hierarchies of education (administrators, college faculties, and elementary and secondary teachers) as well as between Federal and State education agencies and offices appears, on the surface, to have proliferated since the major oil embargo of 1973. This article defines the essential elements of collaboration, juxtaposes these against the prerequisites of energy and education, and recommends new approaches which will maximize the probability of true collaborative energy education planning, resource allocation, implementation, and evaluation. Specifically treated are the types of policy actions, resource distribution and technical assistance roles required of Federal, State, and local agencies and offices. The theories of leading scholars of organizational behavior are applied extensively throughout the article.

INVITED 1.9

"The Forgotten Fundamentals of the Energy Crisis"

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Abstract

The forgotten fundamental of the energy crisis is the elementary arithmetic of growth. The arithmetic is examined and is then applied to answer the question, "What is the life expectancy of known or estimated reserves of several fossil fuels for various reasonable rates of steady growth of consumption of these fuels?" The answers from the arithmetic are enormously more pessimistic than are the typical pronouncments in the public press. A large organized sample of these pronouncments is presented so that students can compare them with the facts and can thus see how essential it is that they make quantitative evaluations of the optimistically erroneous material that dominates much of the public discussion of energy. This paper is well summarized by the quotation from Aldous Huxley, "Facts do not cease to exist because they are ignored."

INVITED 1.10

Energy Activism in Secondary Education

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Abstract

The author is a vocational construction teacher in a small high school in Creswell, Oregon, whose program has attracted over $35,000 in state and federal grant monies to "Improve the Quality of Vocational Education in Oregon." Entitled "Energy Efficient Construction," the program has several timely features including a high enrollment of women in non-traditional roles, utilization of multi-media teaching approaches to serve disadvantaged and handicapped students and employment of energy efficient projects. Students have built, sold and installed domestic hot water solar collectors and systems. Students have built a large passive-hybrid solar greenhouse which may be the only one of its kind built by regular high school construction students anywhere in the country. Students have also been active in presenting their "Energy Road Show" at fairs, special "Energy" days, and at Solwest '80 in Vancouver, B.C. Besides telling of these activities in more detail the paper would deal specifically with:

- sources and approaches for funding energy related projects
- utilizing energy oriented projects as teaching vehicles
- analysis of useful commercial energy media programs
- creating an "energy advocate" in the school district
- design and construction of solar greenhouses for use by horticulture classes and as a heat producer
- involving the community in energy education through adult education classes in solar energy and appropriate technology

SESSION 2: SOLAR ENERGY EDUCATION

2.1 INVITED

SOLAR ENERGY, CURRICULUM DEVELOPMENT AND TEACHER TRAINING

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Abstract:

The study of solar energy is edging its way into school curricula. Experience with Curriculum Development Projects over the last fifteen years has shown that new materials and approaches are most acceptable if they are grafted on to existing syllabuses and more compatible with familiar teaching styles. Locally inspired work seems more likely to be adopted than centrally produced materials. The teachers training process provides a route by which teaching materials can be devised, built and tried out in neighborhood schools. This is true at initial-training level and also at in-service courses.

In Southampton a dozen graduate students training to be teachers in secondary schools were asked to take a lead in developing materials for the introduction of a study of solar energy into the school curricula. Each one was asked to design a piece of apparatus which could be used to investigate aspects of solar energy. A quantitative study was to be preferred where possible. They built

(1) a spherical mirror of mylar
(2) a cylindrical mirror of polished aluminium
(3) a solar still
(4) a survivor's still
(5) a solar oven
(6) a battery of reflectors to compare thermal properties of liquids
(7) 'solar cushions' to illustrate different absorbing powers
(8) an electronic thermometer
(9) a panel of surfaces to display different absorbing powers
(10) a camper's flate plate heater
(11) a fresnel lens collector
(12) experiments to investigate the output of solar cells

Each student then worked with a small group (5 or 6) of below average ability classes. They tried out the apparatus (some worked, some didn't) and they tested their own teaching abilities with unfamiliar children and unfamiliar materials. Each student prepared 'back-up' activities if the sun did not shine.

The following year a series of in-service courses for practising teachers was arranged. The place of solar energy in the science curriculum was discussed and suitable apparatus was designed and built. The teachers extended the students' work and built simple trickle heaters and thermosyphon models. In every case we wished to *investigate* what happened - by trying no glazing, single glazing, double glazing, varying rate of flow and insulation, etc.. Six sets of solar apparatus were then constructed and are now out in ordinary schools for evaluation.

This paper is presented as an example of a way in which students, university staff, teachers and children can work happily together and contribute to the design and choice of effective teaching materials.

Introduction:

The study of solar energy is slowly edging its way into the school curriculum. Experience with curriculum development projects over the last fifteen years has shown that new materials and approaches are most acceptable if they can be grafted on to existing syllabuses and if they are compatible with familiar teaching styles. Locally inspired work is as likely to be adopted as centrally produced materials. The teacher training process provides a route by which teaching programmes can be devised and tried out in neighborhood schools. This is true for both initial and in-service courses. The need for curriculum materials based on solar energy offers an opportunity for this idea to be put into practice.

1. *In-Service and Initial Training of Teachers*
In Britain and many other countries the day of the big Project is over. Teacher educators no longer have an easy source of novel materials to present to practitioners. Nevertheless in-service education is needed. Changes in the future are likely to come about in less spectacular fashion than in the '60s and '70s but the science curriculum must surely change in response to new scientific knowledge, new social demands and improved understanding of effective educational practices. To meet the challenge of these changes teacher training courses will need to change from merely presenting project materials to a more creative style. In the absence of well-defined innovations launched nationally through well orchestrated press releases and TV and radio interviews, interest must be generated locally and personal decisions about courses will need to be made. For these decisions to lead to popular courses and effective thcnage in classroom and laboratory practice, course organisers will have to be well informed. They will need to know about changes in science itself, about the climate of opinion in school and the community and they must also be ready to create rather than present teaching materials.

When lecturers responsible for *initial training* courses are preparing science teachers to enter school laboratories for the first timr they too have for a decade been able to capture interest by extensive use of project materials. But this is becoming less easy since many students will have followed modern O-level and A-level courses in school and they know much of contemporary apparatus and materials from their own experience. Even so, in terms of developing the interest of students in unfamiliar subject matter and teaching styles, organisers of initial training programmes have an easier job than organisers of in-service work. Much that is familiar to an experienced teacher is new and intriguing to a newcomer - and hopes are high on initial training courses. A productive way of capitalising on the optimism and up-to-date knowledge of newcomers and at the same time using the wisdom of more experienced teachers is to bring the two together. No better way exists than to ask them to devise something new which is an improvement on existing practice.

A lecturer in a College or Department of Education now has the chance to influence teaching in three ways:

i) by recognizing the need for curriculum change and facilitating curriculum development at a local level
ii) by arranging meetings of experienced teachers
iii) by stimulating intending teachers to create new materials and approaches.

Many teacher trainers do attempt all three of these tasks but it is not usual for the three to be tackled simultaneously, as part of a coordinated curriculum development-teacher training programme. And yet some of the mistrust which teachers have of lecturers working in their colleges away from the realities of school would be reduced if a *working* partnership were developed between lecturer, students and teachers. At the present time good relationships exist between many colleges and their neighbouring schools. It is usually focussed on students undergoing initial training but an opportunity is often lost. The students practise teaching in school, they prepare their lessons, learn to handle apparatus, computers and audio-visual materials. Much of what the students do is emphemeral; they do not make a long-lasting input either to the educational system as a whole or to their practice school. What is lacking is an expectation by experienced teachers that students (supported by their lecturers) can provide curriculum materials which improve and expand existing resources and which are worth retaining. The lecturers too are reluctant to suggest to teachers better ways of tackling themes in science. They fear that they will be accused of interference or of making unrealistic proposals. If the latter accusation is thought to be valid then it needs to be put to the test.

2. *Energy and the Science Curriculum*

Questions of the supply, conversion and use of energy in the last quarter of the twentieth century offer great opportunities for curriculum development. Energy can be studied in very many ways, not only in physics courses but in other science courses, in science and society options and in history, geography, economics, politics and a whole range of school subjects. Historically however the study of energy has rested firmly in the sciences and nowhere more securely than in physics. An economist or geographer will speak more convincingly if he understands the laws of thermodynamics and the nature of energy changes and losses. On the other hand it is becoming clear that a physics programme which concentrates on an academic study of the laws of pure physics is an inadequate preparation for decision-making in the real world. The study of energy can be enriched by illustrating physical principles by reference to energy conservation and the many ways in which energy can be manipulated to reduce the effects of shortages of fossil fuels. Biology too can be enriched by studying the production of fuel from the bio-mass. In this paper however the emphasis will be on improving physics teaching schemes.

In the United Kingdom there can scarcely be a single secondary school without its 'energy conversion kit'. Many still have copper calorimeters with which to study heat exchanges. All include electricity in their courses. There is a wealth of apparatus in schools and a wealth of teaching experience connected with energy. This is an excellent foundation on which to build and the fact that students in college or university themselves learned about energy using apparatus which is still in use in school means that student and teacher have much in common and that innovations can be made from a basis of common knowledge and experience. The other much less specific knowledge that is shared is the knowledge of the problems of energy supply and distribution which are bound to arise in the very near future. It was in 1973 that oil prices began to shoot up. A look at energy supply and consumption statistics (1, 2) reveals discontinuities in the graphs in or around 1973 and the Club of Rome's (3) assumptions of exponential changes are clearly false. The provision of energy for all in the most convenient and appropriate form has suddenly become a problem and even the certainties of regular growth and decay have been eroded. These factors combined to provide an almost perfect basis for curriculum innovation. There is a need for materials which will help children to become aware of energy issues. There is apparatus available for the study of energy. Teachers, students and lecturers alike understand the laws of energy conversion. The innovation can be an extension of exisiting practice and needs no radical reshaping of syllabuses or examinations. Studies can be organized in problem form and answers can be offered following experimental work or study of resource material. The rest of this article is built around a teacher training programme which grew from an awareness that the study of energy in school can be extended beyond conventional syllabus material. A dozen graduate students (engineers and physicists) were invited to prepare teaching materials and to try them out in school. A year later experienced teachers attended in-service courses to consider and extend the students' ideas and to build some apparatus for their schools. Prototype apparatus was also built in the University and issued to a number of schools who were asked to comment on the strengths and weaknesses of the equipment.

3. *Solar Energy*

The students involved in the first development work were attending a one-year course leading to a Postgraduate Certificate in Education at Southampton University. The possession of a degree meant that their knowledge of physics was sound and that they were technically well-equipped to design and handle apparatus. At the time, solar heaters were beginning to appear on rooftops and studies were being published evaluating performance and cost. Solar heaters heat water; traditionally water in school physics is heated in beakers or calorimeters but the usual 'heat lost' and 'heat gained' calculations can be carried out as easily with solar heated water as with water heated by a Bunsen burner. Here was a way of covering an important concept in a context which had immediate significance for the boys and girls. Similarly concave mirrors appear in many syllabuses. We used big ones in the sunshine instead of tiny ones in a laboratory. Impedance matching of electrical supplies and loads is an important topic at more advanced levels. We used solar cells not batteries; they are more interesting and thier characteristics change with incident radiation. Questions can be asked about solar cells which lead to worthwhile practical investigations and which call for quite a depth of understanding to answer convincingly. The concept of efficiency is fundamental in the thinking of most engineers and appears in every school physics course. A solar system adds a new dimension to efficiency studies. It can be measured but if energy is free efficiency is of no consequence. Or is it? Discussion is not easy to provoke in conventional physics lessons but facing a question like this few classes will remain silent. At the end they will be much wiser about efficiency, cost-effectiveness and environmental impact.

A central tenet of our thinking about physics teaching is that it should be firmly based on experience and that practical work which involves an investigation is more valuable than an experiment which merely verifies or where the conclusion is implicit in the apparatus or the recommended procedures. We also feel that some numerical measurement and calculation add strength to a boy or girl's ability to grasp physical concepts. These educational principles and suggestions for worthwhile experiments were discussed with the student teachers. Each was invited to choose an experiment using solar energy, to design and build the apparatus for it and to put it in a teaching context. The sun alas does not always shine in England and every student had to have back-up activities if the classes were forced to stay indoors. Some of these were parallel experiments. The effects of radiation on coloured surfaces can be studied in sunlight or in a laboratory and so can heating and cooling. Some activities were investigations based on books and papers. We built up a large collection of popular articles drawn from newspapers and magazines and even on a bad day there was much for the school classes to do. But we were fortunate and on the ten days we were in school we were never driven indoors.

The reason for the production and testing of curricular materials in solar energy are many and can be summarised as follows. Sunlight is available almost everywhere, solar energy is in the public eye at present and is a potential contributor to local and national energy supplies. Its study raises scientific, technical and social questions. These can be considered at an elementary, descriptive level, at an early stage of the study of physics and right up to advanced and graduate levels. At any stage personal investigations can be undertaken and they can proceed to a level of theory and analysis appropriate to the abilities of the investigators. The sun is a source of radiant energy across a broad spectrum, it is a source of heat and light which can substitute for conventional sources allowing syllabuses to be extended and enriched without suffering radical change. Numerical measurements can be made with solar apparatus and quite easy algebraic manipulation enables heat transfer equations to be used to calculate constants and parameters of the equipment. Solar energy is a theme par excellence with which to encourage student teachers to develop their ideas and to make a positive offering to the educational system.

4. *Theory into Practice*

Student teachers need pupils to practice on and ours needed to try out their ideas with classes or ordinary children in an ordinary school. We approached a secondary comprehensive school in which a physics teacher was known to be an alternative technology enthusiast. Two classes totalling fifty children were allocated to us for one afternoon a week for ten weeks. They were aged about fourteen and were of average and below average ability and motivation. Many of them were looking forward to dropping physics for good at the end of the term. Such a class is not an easy one to handle and the boys and girls were taught in small groups so that no student ever had more than half a dozen children to work with. A small group enables a student to explore relationships and to try out different approaches without risking serious class control problems. It also allowed time for them to assess their success and failures with the experiments and with their teaching. In the main a student stayed with his own piece of equipment throughout the term. He was able to refine his presentation continuously as different groups came to him each week. On the few occasions when all fifty boys and girls were addressed at the same time it was the writer who did so.

The students were asked to choose and develop an experiment and to prepare a lesson along lines which will be familiar to teacher trainers. They considered what particular benefits the work offers (the aims) in terms of the processes of science (definition of problem, skills developed, design, choice, reporting, etc.), in terms of the learning of subject matter (absorption of radiation, optics etc.) and in terms of social relevance (contribution to energy in the home, awareness of economic significance etc). They prepared introductions, presentations and questions. It was pointed out that solar experiments often take a long time and that the boys and girls must be kept occupied whilst the experiment proceeded. We are not keen on stereotyped worksheets which need only a few words to be written or deleted so a variety of activity was called for. Wherever possible frequent involvement with the apparatus was arranged. The best experiments were those where adjustments had to be made frequently or where a series of readings (usually of temperature and time) were called for. Otherwise boys and girls were asked to draw the apparatus, label a diagram, refer to books or offprints, make notes on the experiment or to discuss with a teacher what was happening. Table 1 is a list of the experiments attempted.

Most of the experiments worked. One or two did not. The "camper's water heater" — a concoction of hosepipe, polythene and a plastic bucket — resolutely refused to thermosyphon but the level of involvement of the children in constructing and adapting the system fully justified its inclusion. At the outset I was sure that the solar oven was badly designed and would never cook anything. Again its very inadequacies challenged many members of the group to improve it. The level of invention on the part of the children was remarkably high and the feeling of success when an egg was finally cooked justified the time that had been taken. The vacuum creating a large concave mirror from a washing-up bowl and reflective mylar film leaked away and the radius of curvature of the surface slowly increased. But this was turned to good effect. As the focal length changed so the children had to increase the distance between the mirror and the can that was being heated. They learned in an active way that the curvature and focal length are intimately connected. We still have not solved the sealing problem but the mirror is so good that it is one of our greatest successes — and the vacuum holds long enough for the mirror to be used throughout a double period.

Overall the attempt to introduce a practical study of solar energy into a school curriculum was entirely successful. The attitudes of the University students were changed and many of them have continued to work with solar energy in their own schools. The children enjoyed working in the sunshine at problems which had a practical application. School staff from many different disciplines stopped to have a word about progress and we even picked up one very enthusiastic girl who should have been at lessons elsewhere. One big problem which arose was storage of apparatus. Space is not plentiful in school laboratories. The apparatus could not be left outside overnight for fear of damage and the temporary storage in the school hall was unsatisfactory as a long-term measure. As our apparatus has developed so it has got smaller. There is no need to have many square metres of surface and many litres of water. Effects are often observed more quickly on a smaller scale and the storage problem is eased. The children we worked with were not examination candidates in physics so we were free to use time as we wished unrestricted by demands to get through a syllabus. Even so we felt that the work related so well to O-level and CSE examination syllabuses that time in the sunshine for even these candidates would be well spent.

A futher problem was pointed out by the students. Working with four or five children is easy. The organization of a whole class in the hands of one teacher would be much more difficult. The distribution and erection of apparatus would need to be very carefully controlled and the scheduling of work would need to depend far less on the continuous presence of a teacher. Perhaps more detailed worksheets would have to be written or the variety of activities would need to be curtailed. Experienced teachers working with whole classes were needed to look into this.

5. *Extension to In-service Education*

The experiment with student teachers demonstrated that a study of solar energy in school is worthwhile but that practical problems remained. Prototype apparatus had been built which needed refinement and production in larger quantities. Laboratory suppliers are now supplying some solar apparatus but it is much cheaper to build it oneself and a teacher's own preferences can be incorporated into home-made apparatus. Three different needs of experienced teachers were recognised. They need to know more about the whole energy supply question and the economic and technical issues behind it. They need apparatus with which to work and they need help in organising lessons outdoors. Two evening courses were arranged for teachers each lasting for ten weeks. The first was a series of lecture-demonstrations covering not only the theory and practice of small-scale energy provision, mainly solar and wind, but also discussion of the ways in which the study of energy in school can be incorporated into and extended from existing work. The second course was entitled "Build Your Own Solar Collector" and a group of teachers attended a purely practical course in which materials and tools were provided so that teachers could take collectors back to their schools. At the same time they were introduced to other solar devices.

The original work had shown that more quantitative investigations could be carried out if there were an instrument which could measure solar radiation density. A commercial solar pyranometer was purchased as a standard and a much cheaper version was designed and built. The ability to measure incident radiation in watts per square metre made a whole range of new calculations possible. The calculation of efficiencies was now easy. We also needed a cheap, robust thermometer. Mercury in glass thermometers are becoming too expensive for schools to provide and they proved too fragile for the outdoor environment. As their price falls so electronic thermometers are becoming a better buy for class use. To keep costs down we have designed and built our own electronic thermometer for use outdoors. We also realised that if children were to make the most of their energy studies they needed more data. A collection of data sheets was therefore prepared (4). The facts, figures and graphs contained therein were sufficient to permit advanced study and calculations to be performed and enough information was given to help in the design and construction of working installations. There is still much to be done and we have only started on a widespread dissemination of our ideas. At the time of writing six sets of solar apparatus are in schools for evaluation by teachers, occasional meetings of teachers are being arranged and visits are being made to schools. The apparatus and teaching materials are likely to be adapted and developed continuously and we are confident that the interaction of University staff, experienced teachers and students-in-training will continue into the foreseeable future and that a study of energy covering far more than the physics of the 16th to 19th centuries will slowly come to be looked upon as an essential component of science courses.

Apparatus	Illustrating Physical Principles
Coloured aluminum plates	Absorbing power of coloured surfaces
Solar cushions	Absorbing power of coloured surfaces
Steam engine	Energy conversion
Solar still	Evaporation
Survivor's still	Evaporation
Fresnel lens	Converging light and heat
Washbowl mirror	Focussing by concave mirror
Bicycle wheel mirror	Focussing by concave mirror
Headlamp reflector array	Heating, effect of colours, insulation
Camper's water heater	Convection
Flat plate heater	Heating, convection, efficiency
(i) thermosyphon	
(ii) pumped	
Solar oven	Heating, efficiency
Solar cells	Internal resistance, impedance-matching, efficiency

Table 1. Apparatus and Experiments
Brief descriptions of the apparatus and outlines of possible experiments are available from the author at the Department of Education, University of Southampton, Southampton, S09 5NH.

References

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D.C. Ion 1981 Graham and Trotman

2. Energy. Readings from Scientific American
S. Fred Singer 1979 Freeman and Co.

3. The Limits to Growth
Dennis L. Meadows 1972 New York, Universe Books

4. Energy Data Sheets
Cliff Day 1981 Southern Science and Technology Forum, Southampton University

2.2

FUN AND FRUSTRATION — PHYSICS EXPERIMENTS IN PASSIVE SOLAR DESIGN

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Abstract:

Six original, in-the-environment, physics experiments measuring passive solar parameters are described. They are: a) Site evaluation, b) Winter tree shading, c) Window transmission factors, e) Surface color — light-to-heat conversion, f) Temperature-cycle phasing by house orientation, and g) Measured solar gain for multiglazed windows. The instruments, constructed at home from largely recycled or

renewable materials, received excellent student ratings. Information sharing between lab groups, fostered by the laboratory manual, expands the pool of relevant data for analysis and for recording in design notebooks. Manuals, in preparation, for apparatus construction and for student experiments are mentioned.

Fun and Frustration

Six original, out-in-the-environment experiments measuring passive solar parameters have been developed by the author for his physics class, Energy Efficient Living. Each measurement and its analysis suggests methods for optimizing passive solar design under local conditions. Although the experiments and the laboratory manual were developed at a liberal arts college, the environmental information gained can serve students from technical school levels right up to university graduates in architecture. As an aid to others in setting up similar experiments, an equipment construction manual and a student laboratory manual are being prepared this summer.[1]

The "frustration" aspects of these six experiments lie in their weather dependent scheduling, a familiar phenomenon among solar professionals. The laboratory manual includes several indoor experiments, not discussed here, as foul weather alternatives. But the "fun" aspects of these experiments is sparked by their out-in-the-field character. And secretly, the instructor gains valuable solar design information — from student efforts!

Two experiments pertain to site evaluation: one studies winter tree shading, the other, skyline analysis. A second pair of experiments measures design parameters: light-to-heat conversion by surface colors, and light transmission throug windows. The last two experiments use working models to study passive home dynamics: home orientation and temperature-cycle phasing, and thermal gain-loss factors as a function of glazing multiplicity.

The lab manual engenders a cooperative philosophy — each group's experiment differs slightly from that of any other group. All information is finally pooled for individual analysis. This data exchange serves several useful purposes. First, it inspires accuracy — everyone will see and be affected by each group's results. Second, it yields a wider perspective for analysis than one group could possibly obtain. And last, it provides more complete reference material to record in solar design notebooks.

Let us now view the experiments individually.

A. Winter shading by deciduous trees (requires clear weather)

Fig. 1 illustrates an instrument for tree shade analysis which consists of a 1.06m^2 white screen scattering an integrated light sample onto a photovoltaic cell. By comparing light intensities measured in the shade zone with those measured in direct sunlight, the percent of light penetration can be readily evaluated. A measurement cycle includes: direct sunlight from each side of the tree, three samples from the tree crown shadow, and five samples through the broadest shadow zone. Shared data from different trees consist of averages from three of these measurment cycles on a single tree. Fig. 2 is a representative sample cut from the shared-data-table in the lab manual.

B. Solar-site skyline analysis (can be done on an overcast day)

Sketches from Mazria's *Passive Solar Energy Book*[2] inspired the skyline analyzer. Bennet Sun Angle Charts[3] provided primary data for preparing the sun position graph which was adapted to the cylindrical geometry of this skyline tracing screen. A special feature of this sighting device is its single "quadrant" design. Since our summer sun at 39° north latitude runs through 240° of azimuth, a Mazria-like screen would give the viewer a 240° embrace. The tracing unit spans only the 120° eastern "quadrant," and then after reorientation (and changing tracing color) a west "quadrant" trace completes the skyline. With these double tracings overlaying the sun position graph mentioned above, sunrise and sunset times can be estimated for each month of the year. The surface level built into the "horizon plane" guarantees horizontal alignment. North-south alignment employs Polaris, the north star, to identify "true north." Young couples relish this prelab exercise! In fact, students rate this experiment "the most enjoyable" and the "best-information-for-time-spent" experiment of all.

C. Window analysis (clear day — adaptable to indoors)

Fig. 4 illustrates a glazing goniometer for measuring light transmission efficiencies for various glazing materials at incident angles from 0° to 75° in 15° intervals. A photovoltaic cell reads relative intensity between direct illumination (with glazing material removed) and transmitted intensity (with the glazing material in place) clearly demonstrating obliquity effects. A second part of this experiment demonstrates the effective-area cosine law. This is accomplished by measuring areas of light beams transmitted through cardboard "windows" of various shapes: rectangles, circles, triangles, etc. for all goniometer angles mentioned above. Different groups analyze different shapes to demonstrate the general validity of the cosine law. With six data points between 0° to 75°, accurate cosine curves and glazing attenuation graphs can be easily sketched.

D. Surface colors — light to heat conversion (clear day exp.)

An inexpensive apparatus for studying relative light-to-heat conversion efficiencies employs a corner-reflector to multiply the sun by three or four. The corner frame was made of double strength corrugated cardboard to which aluminum foil reflectors were "glued" using paint remnants from home. The gluing operation was carried out prior to painting the back surface since "glue" solvents must dry through the cardboard — foil is impervious to solvents. Once the foil-to-cardboard bond was dry, the back of the frame was painted to reduce warping. Because the foil bond was weak, duct tape was used as edge binding. The tape both seals the edges and enriches the appearance, a feature worth considering when collecting lab fees.

Colored water containers of this experiment were 3.78 liter plastic milk jugs with screw caps. The miniscule cost of these throw-away containers was fully compensated by their abhorance of paint. My best paint strategy has been to undercoat with alkalyd base followed by what-suits-your-fancy. Even so, peeling persists. Coatings of lacquer, urethane, latex, and oil base paints all peel like cabbage leaves from ployethylene jugs. The alkalyd base coat peels more like ripe tomatoe skins — a considerable improvement but hardly justifying a lifetime warrenty unless it be for the lifetime of the paint. Readers discovering better options are requested to communicate with the author.

These intimate construction details are shared here because this system can demonstrate solar benefits that all can afford. At Camp Cedars, Missouri (August 1979) I heated 7.56 liters of water in a two-gallon jug using a corner reflector. The water jug, cocooned in a sleeping bag, was too hot for shaving the next morning!

Returning to the experiment —. Two aspects of light-to-heat conversion are measured with this apparatus. First, the light-heat conversion rate can be measured when water and ambient temperatures are equal. At that instant thermal conduction and thermal radiation are in near balance with their environment and energy transfer, measured in the water, is from light-to-heat conversion alone. The second measurement of interest is the steady-state temperature for each surface color. In the future this part of the experiment will use containers with larger surface-to-volume ratios. They need to reach steady state before either changing sun angles or cloud cover on the slow-heaters destroy the validity of the comparisons.

E. Passive home response time as a function of orientation, and F. Solar gain-loss parameters as a function of window glazing multiplicity (preferably clear weather exp.)

These experiments were run concurrently for 48 hours during which the air and water temperatures were measured almost hourly on six miniature passive solar homes. Individual couples "volunteer" for scheduled times during this night-and-day vigil. Each model was an ice chest with: two added layers of foil-backed urethane insulation 1.8 cm thick, 3.5 liters of water in identical black jugs, and glazed with rigid plastic. In experiment E. three identical "homes" were oriented east, south, and west. Measured indoor temperature transitions phased progressively from east-facing to west-facing units as expected. But to the surprise of the novice, peak temperatures always occurred near the end of the direct solar input period, not at the peak power time as common sense suggests. These homes were so well insulated that the loss-gain balance, i.e. the temperature peak, occurs after direct solar gain has dropped quite low. Such revelations turn students from "design by feel" to design by physics — most acceptable in our department.

The second experiment analyzes solar gains for single-, double- and triple-glazed south facing windows. It is the most sophistiated experiment of the set. First, each unit's loss factor must be computed using nightime data. After establishing the loss factor, daytime thermal losses can be calculated. Then daytime losses added to the water gains give the measured solar input. For nonscience students this analysis requires careful guidance from the instructor. But through it the student reviews: thermal conduction formulas, the mass storage formula, input-output continuity equation, and the instructor's patience. With all its difficulty, this experiment still rates tops in pedagogic logic!

And now for a few closing comments. Witchcraft of exotic instrumentation has long masked the innate simplicity of solar design — a simplicity "understood" by cats in the sun and bats in a cave. In this instance simple homemade instruments break this modern tradition. Each device has been constructed, six-fold, by the author — at home — from simple materials: wood, cardboard boxes, food cans, milk jugs, rubber bands, wing nuts, nails, aluminum foil, paint etc. And yet, each produces necessary local information for intellegent solar design. In a quarter century of teaching, my most rewarding student evaluations have come from these experiments. Student praise of the apparatus has been uniformly excellent. Simplicity of design belies the rigorous thought being provoked and the value of the data obtained — upgrading both solar knowledge and analytic skills. I present these ideas not to sell manuals but to join world educators in selling effective energy use to a shrinking planet. By inspiring tomorrows leaders through our own commitment we squarely confront the challenges ahead!

[1] Inquiries for information on the apparatus construction manual and the student laboratory manual should be addressed to: Publication Dept. F.I.R.S.T. Inc. Rt.1 Box 193, Dow, IL 62022 USA.

[2] E. Mazria, *Passive Solar Energy Book*, (Rodale Press, Emmaus, PA, 1979), pp. 267-287.

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2.3

NATIONAL SOLAR WATER HEATER WORKSHOP PROGRAM

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ABSTRACT
The National Solar Water Heater Workshop currently sponsored by the U.S. Department of Energy started with an idea that the principal author had back in 1977 when he built his own solar water heater. The simplicity and effectiveness of the solar water heating system moved the author to assign as a student project, in the Fall of 1977, the development and selection of suitable hardware components. That same Fall, a proposal was submitted to the U.S. Department of Energy Office of Small Scale Technology, to assist in starting the local workshop classes. The grant was awarded, and classes were started in the Fall of 1978 at Arizona State University. The classes since that time have spread throughout may part of the southwestern United States. The Office of Small Scale Technology was pleased with the success of the local workshop program, and supported the author's suggestion that the local program could be replicated on a national basis. That support resulted in the present National Solar Water Heater Workshop Program sponsored at the rate of $600,000 for the first year and $400,000 for the second year.

The specific goal of the workshop program is to start 91 classes over the next two-year period with at least one class in each state of the union, and one class per population center of one million persons. At the end of the second full year of the grant program, it is anticipated that over 50,000 students will have participated in the workshop and will have completed the fabrication and installation of a personal solar water heating system. An additional goal is to have a pre-tax first cost not to exceed $500 for the open system and $800 for the closed system.

The philosophy of the program is to use the money as seed money to trigger a ripple effect emanating from the 91 class sites to the entire U.S.A. If the ripple effect is only partially as successful in other parts of the United States as it has been in Arizona, the program will spread to the entire U.S.A. A central thrust of the program will be to assist small businesses, with at least one per state, gear up to profitably supply hardware directly to the workshop class participants. The government money will be used to prepare the training materials, for personnel training, and for component and system certification testing as required to obtain building permits and to exercise the right to collect tax credits.

The implementation plan will be a cooperative one between Arizona State University and each of the State Energy Offices throughout the United States. The State Energy Offices will provide the National Workshop team with the names of prospective workshop class sponsors as well as prospective hardware suppliers. Members of the Arizona State University team will meet with the State Energy Offices as well as the organizations interested in either sponsoring the workshop classes of supplying hardware. The purpose of the meeting will be to clearly illustrate the benefits to society, to the individual homeowner, to the hardware supplier, and the workshop sponsor to continue the workshops so long as interest remains. The workshop sponsor will also receive recommended selection criteria for workshop instructors and samples of successful news releases publicizing their upcoming workshops. When the first workshop class has been filled and the instructors selected by the sponsor, a team from Arizona State University will go to the class site and train the workshop instructors.

Through this ambitious program, sponsored by the U.S. Department of Energy, a significant reduction in our dependence on non-renewable energy resources is expected.

1. Introduction

The use of solar energy for domestic solar water heating is generally believed to be the first universal application of solar energy. Despite a long-standing knowledge of these basic principles, widespread use of solar energy has not yet resulted despite ever-increasing utility costs and dependence on foreign sources of energy. The major reason for this situation is believed to be an educational gap between this technology and its universal application.

2. History

When the principal investigator moved to Arizona in 1975, he was shocked that there was virtually no solar activity despite the abundance (if not over-abundance) of solar energy. Practicing what he taught, the author fabricated solar collectors out of wood and sheet metal for his own home and knew firsthand that solar water heating could be simply accomplished, that it was practical, and was extremely cost effective. Design for a warm climate was finalized (1, 2) and workshops were started in the spring of 1978 at the ASU College of Architecture aided by an $11,000 grant from the Department of Energy Office of Small Scale Technology.
Four graduate stduents assisted for several semesters in refining the concepts and development or selection of improved components for the solar water heater system.

Since the major problem inhibiting application of solar energy was perceived to be educational, a means was sought to directly resolve this problem. The concept of a workshop (3) evolved — not to just discuss solar as so many workshops at that time did — but to achieve actual meaningful results. Three pilot sessions were accomplished which demonstrated that the concept was valid and that homeowners could, in fact, understand and accomplish fabrication, installation, operation and maintenance of their solar water heaters. Now men and women of all ages have participated in the workshops.

Due to the demonstrated success of this program, DOE approved a one-million dollar two-year national program with funding at $600,000 for the first year and to be funded at $400,000 for the second year.

3. The National Solar Water Heater Workshop

The NSWHW (4) involves a government-educational institution-private sector partnership. Government, through this grant, provides the seed money over a two-year period to demonstrate that such workshops can result in the installation of solar water heaters, most of which would otherwise not have been installed. The success should stimulate educational institutions and the private sector to continue to expand the effort. The educational institutions have the opportunity, as part of their outreach to their communities, to apply their effective training skills in pursuing an important national goal. And the private sector, mainly hardware suppliers, sells the equipment which the homeowners need.

The specific goal of the workshops program is to start 91 classes over a two-year period with at least one class in each state and one class per population center of one million persons. An additional goal is to have a pre-tax first cost not to exceed $500 for a warm climate and $800 for a cold climate system.

The philosophy of the program is to use the funds as seed money to trigger a ripple effect emanating from the 91 workshop locations to the entire country. If the ripple effect is only partially as successful in other parts of the United States as it has been in Arizona, the program will rapidly spread. A central thrust of the program will be to assist small businesses, with at least one per state, to gear up to profitably supply hardware directly to the workshop students. The government funds are also used to prepare the training materials and for component and system certification testing as required to obtain building permits and to enable tax credits.

4. Educational Materials

Every participant in the NSWHW program; educational sponsors, hardware suppliers and homeonwers, have specialized educational requirements. To assure that these requirements are met, a number of educational packages have been developed.

(a) Media Package (5). A media package has been developed to help educational sponsors promote the workshop in their area. Experience with the Phoenix workshop suggests that an effective media is newspaper coverage as a public service. Sample news releases and examples of successfully-placed media stories are included. Also included is a twelve minute film which explains the interaction of the workshop participants.

(b) Hardware Supplier Handbook (6, 7). Two Hardware Supplier Handbooks have been prepared for hardware suppliers — a "pumped recirculation" freeze protection and an "anti-freeze" freeze protection. These handbooks outline the responsibilities of the hardware suppliers and include a complete list of materials, specifications, sources, description and illustrations of each component in the system.

(c) Tape/Slide Narrative (8). A Tape/Slide Narrative in conjunction with a Student Handbook (9, 10) will be used to explain fully each step of installation, operation, maintenance and trouble-shooting of each system. The tape/slide format was chosen to assure complete coverage of all essential details and consists of 180 slides, requiring three hours for presentation. The slides are carefully designed to give the students a visual picture of each step or component and how it fits into the system.

(d) Student Handbook (9, 10). The Student Handbook is designed to follow along with the tape/slide narration, and includes a detailed explanation of each step and component. It is the student's permanent record of the installation, operation, maintenance and trouble-shooting steps and is invaluable to the student's success in the workshop.

(e) Educational Sponsor Handbook (11). The Educational Sponsor Handbook includes information pertaining to the instructional program, a description of the required tools and equipment, discussion of thermal performance and hardware systems, suggested criteria for instructor selection and legal liabilities while the students are on their premises.

5. Workshop Implementation

The 91 locations have been placed in an order of probability of success as measured by population, tax credits, thermal performance, and cost effectiveness utilizing the University of Wisconsin "f" Chart Analysis Program for thermal and economic analysis. Educational institutions are desired as workshop sponsors: mainly universities, colleges and community colleges. They are now, and will continue to be, integral parts of their communities; have strong reputations; and already have many educational and training activities for the adult populations.

The implementation plan is a cooperative one between ASU and each of the State Energy Offices throughout the United States. The SEO's provide the NWSHW team with potential workshop class sponsors as well as potential hardware suppliers. Members of the ASU team meet with SEO's and the organizations interested in either sponsoring the workshop classes or supplying hardware. The purpose of this meeting is to clearly illustrate the benefits to society, to the individual homeowners, to the hardware supplier, and the workshop sponsor to continue that workshps. The workshop sponsor is also given recommended criteria for workshop instructors and samples of successful news releases which can be used to publicize their upcoming workshops. When the first workshop class if filled, and instructors selected by the sponsor, a NSWHW Field Representative trains the workshop instructor(s) and critiques and evaluates the conduct of the workshop.

6. The Workshop

The actual conduct of the workshop is an intensive program requiring of the student about 11 hours during two days. It consists of two elements; a classroom session, usually Friday evening, of 3 hours to receive the tape/slide presentation in addition to a free intechange between the instructor and students. A Saturday laboratory session of eight hours is devoted to students fabricating their collectors and plumbing components with thorough instruction and close observation by the workshop instructor. The instructor also conducts a quality control inspection of each assembly as it is completed.

7. The Solar Hardware

Nationally, the solar hardware consists of two systems: 1) "Pumped Recirculation" freeze protection and 2) "Anti-Freeze" freeze protection. The choice depends on a location's climate. In a warm area such as Phoenix and at other locations with about the same number of days when temperatures reach freezing, the pumped recirculation system is the most cost effective. All methods of freeze protections for the colder regions have been evaluated. A system utilizing a closed "double loop" fail-safe heat exchanger (12) and ethylene glycol as the heat transfer fluid has been selected for the cold climate system (Fig. 2).

8. Conclusions

Through this ambitious program, sponsored by the U.S. Department of Energy, the current gap between solar technology and its application will be narrowed. A significant reduction in our dependence on non-renewable energy resources is expected. United States citizens, in a measure, can avoid the burden of ever-increasing utility costs and this program can directly contribute to their peace and tranquility.

9. Acknowledgements

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2.4

A UNIVERSITY LEVEL INTERDISCIPLINARY SOLAR ENERGY USE COURSE

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Abstract
The format is presented in the Department of Mechanical Engineering at The University of New Mexico with emphasis upon architecture and energy conservation resulting in a three point synergism. The course, ME-385, is presented in five parts; and overview of solar technologies, building heat loss methods, the solar resource, active solar systems, and passive solar systems. Grading is judged upon performance in vocabulary testing and paper presnetations which include calculations and written portions. Basic goals are three fold; to inspire further study in solar technologies, to organize and clarify fragmented private study, and to create an aware consumer group. The accomplishments of the course have yet to be fully realized. The class has grown from 50 to over 80 students. Student surveys have shown a high level of excitement for the credible, in-depth overview presented in the course. Teaching the course had identified the need for more detailed courses in the Mechanical Engineering Department and School of Architecture at UNM. Other colleges on campus also require invididual lectures on solar technologies. Needs and improvements to the course include extensive visual media material, product examples, tours of installations and visiting lecturers.

A. Introduction
The Department of Mechanical Engineering at The University of New Mexico offers an interdisciplinary course on solar energy use for the layperson. The prerequisites are basic algebra and a sophomore or higher class standing. Students from nurses to business majors enroll for the course. Occasionally, people are allowed to enroll from the community at large, without other university involvements. The course is structured as a forum for the promotion of solar energy use in conjunction with a three point convergence, or synergism, of mechanical engineering, architecture and energy conservation.

B. Presentation
The course presentation is in five parts or sections. Section I is an overview of solar technologies at large, regardless of its scale in application. Sophisticated solar technologies such as Central Receiver Systems, Ocean Thermal Gradient Systems and photovoltaics are reviewed. The more immediately commercially viable solar technologies of wind power, biomass conversion and desalination are presented. Also discussed in Section I are the concepts of Net Energy Analysis as a decision-making tool and the inevitability of a hydrogen solar-based economy in the future. Section II is referred to as the "nuts and bolts" section of the course. A review of standard building heat loss methods is covered per ASHRAE, et. al. Stressed is the idea of energy conservation in building design before solar augmentation is employed. Good building design is emphasized throughout the remainder of the course to bring a practical, human scale to the subject of solar energy use.

Section III reviews the solar resource, i.e., where the sun is, when and how much energy is acutally available. Also discussed is a basic understanding of the electromagnetic spectrum for a layperson's interpretation of "short wave" energy vs. "long wave" energy. This concept is important for understanding the so-called "greenhouse effect" of a solar collection device.

Section IV overviews active solar systems utilizing off-site energy to operate the system. Collection devices, storage systems and distribution and control methods are presented. Teh most economically viable active solar systems producing domestic hot water are reviewed in great detail.

The final section is a layperson's study of passive solar tehcnologies. These systems are users of on-site energies, utilize natural energy flows and can require some owner participation. These passive systems include direct gain, mass-storage wall and sunspace or greenhouse systems.

C. Grading
Since the course is desinged for non-engineering majors, a slight shift in grading emphasis is necessary. The key factors of organization, clarity of presentation, and logical thought processes are emphasized. Six vocabulary quizzes are given during the semester constituting 40% of the final grade. Two papers are also required. The first paper, stressing organization and heat loss calculations is due at the mid-term. The final paper, in lieu of a final exam, stresses composition and building design utilizing solar augmentation. These papers are worth 40% of the final grade. The remaining 20% is judged by class attendance, 10% and class participation, the final 10%.

D. Goals
The goals of the solar energy use course are three fold. The first is to provide a forum to organize and clarify fragmented private study of solar energy. All too often, people can become confused and dismayed at the plethora of sometimes conflicting information available on solar energy use. The second goal is to stimulate demand for further courses in solar technologies. The solar technologies and their implementation cross many disciplines in the university environment. This emerging industry needs particular detailed study in all disciplines to have a significant impact upon our energy problem. The final and perhaps the most important goal is to create an aware consumer group. We are living in a time when there are many "snake oil artists" barking the benefits of solar devices and systems. An educated consumer is the best defense against these charlatans.

E. Needs

A single but far-reaching need has been identified as a result of teaching the solar use course. Due to growing interest in the subject, as reflected in increased enrollments of 60% in less than a year, a comprehensive solar/energy/environmental engineering/architectural degree must be considered. Institutions of higher learning must always lead and stimulate new disciplines for tomorrow's employment and humanitarian needs worldwide.

F. Improvements

Improvements in the course are necessary in five areas. One, the class size of 80 students is too large to devote individual attention at all times. Second, visual medial material is desired with money to afford these materials being more scarce than materials. Third, a cross section of solar products and devices for a hands-on understanding is very desirable. Fourth, tours of all types of solar installations and companies would be very informative. Fifth, an occasional visiting lecturer could relay other experiences and understandings of solar technologies.

G. Conclusion

Througout the semester, the mechanics of solar energy use are discussed in detail for the layperson. Before long, and sometimes immediately, the logic of extensive solar energy utilization becomes apparent to the student. The student's next question is "Why isn't solar being utilized more?" Anyone studying solar energy use comprehensively will be forced to this question and the inevitable answer. The question of more utilization of humankind's most abundant energy resource is a political question discussed in the last class of the semester. The politics of a nation determine its values, attitudes and judgements of worthwhileness. These United States of America, the one time technological innovator of the world, lacks the political courage and strength to capitalize upon the most marketable industry humnakind has ever known, due to the control of vested political interests. This is why the study of solar energy use and its utilization is not more comprehensive.

2.5

SOLAR ENERGY EDUCATION FOR THE CONSUMER*

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1.0 Introduction

Because of abundant sunshine, rapid population growth, dependence upon imported liquid fuels, and a history of solar utilization, Florida was chosen as a pilot state for a special solar energy promotion campaign for industry and a corresponding education program for consumers. The program was entitled "Project Sunshine."

The Florida Solar Energy Center (FSEC), under contract with the Southern Solar Energy Center (SSEC), was given specific responsibility for informing the solar industry of the proper methods of sizing and installing solar water heaters, and of increasing the level of consumer information and confidence in solar equipment.

To meet these objectives, the following activities were undertaken between October 1979 and October 1980.

Thousands of information brochures and consumer guides were distributed; several installation short courses were offered regionally to the solar industry; approximately twenty consumer seminars were conducted throughout the state; six newspaper columns were prepared and distributed to over 60 Florida newspapers; appearances were made on a number of radio talk shows; and two special programs for representatives of the news media were offered.

Populous southeastern Florida, including Dade, Broward and Palm Beach counties, was chosen as the initial target area for Project Sunshine, and activities were conducted there during the last quarter of 1979. These efforts were followed by Project Sunshine II in Central Florida (Orlando to Tampa Bay) and Project Sunshine III in North Florida (Jacksonville) during the first three quarters of 1980.

2.0 Solar Information Brochures

A Florida Solar Energy Center information brochure entitled "Solar Water Heating: A Question and Answer Primer" was printed in large quantities for distribution as part of this program. The document addressed the most commonly asked questions about solar water heating and had received widespread public acceptance in previous FSEC information dissemination efforts.

Approximately 25,000 of the brochures were distributed as follows:

Distribution Mechanism		Aproximate Number
Individual Mailings		3,800
Source of Request and Number:		
Phone (response to mailings)	100	
Utility Mailers	3,600	
Bank Coupons	100	
Southern Solar Energy Center		1,000
Project Sunshine Workshops/ Consumer Seminars		2,000
Other Workshops		2,000
Industry Members/Vendors		2,000
County Consumer Affairs Offices		1,500
Energy Fairs/Exhibits		8,200
Educational Institutions		3,500
Utility Companies		1,000
	Total 25,000	

2.1 Solar Information Brochure — Conclusions

1. The use of utility bill mailers was by far the most effective mechanism for soliciting requests for solar information through individual mailings.
2. The bank coupons and other advertising methods resulted in a relatively insignificant demand for the brochure.
3. The total distribution of approximately 25,000 brochures and the consistently favorable response far exceed expectations.
4. The overwhelming majority of the brochures were distributed through workshops, seminars, the solar industry, county offices, energy fairs, educational institutions, utility companies and grassroots organizations, rather than in response to individual mailings.

3.0 Consumer Guide

A larger booklet entitled "Turning on the Sun: a Comprehensive Consumer Guide to Solar Water Heating," was developed by FSEC for the more serious prospective buyer and was an important handout for the consumer seminars in Central and North Florida. It contained much more detailed information on comparison shopping, warranties, the solar contract, and troubleshooting. Approximately 2,000 copies of the document were distributed. Written requests for this booklet are still received on a daily basis.

3.1 Consumer Guide — Conclusions

The consumer guide improved Project Sunshine and helped satisfy the needs of many serious prospective buyers of solar equipment.

4.0 Solar Installation Short Courses

FSEC conducted three one-day solar installation short courses, which were shortened versions of the very successful three-day programs offered by the Center. In addition to the shorter length, these workshops differed from the typical training programs in that invitations were sent only to the solar industry, and there was no registration fee. Instructors from FSEC and industry presented both lectures and hardware demonstration, and course content paralleled that of the three-day program. Attendance at the short courses was 14 (at Ft. Lauderdale), 19 (at West Palm Beach), and 24 (at Homestead, near Miami), for a total attendance of 57.

4.1 Solar Installation Short Courses — Conclusions

1. The short courses received very high evaluations by the attendees, but required great effort to transport and setup the instructional hardware.
2. Future efforts should be directed at a far broader target group. The larger group should include solar installation, plumbing, sheet metal, air conditioning, roofing, swimming pool and building contractors, and building inspectors.

5.0 Consumer Seminars

FSEC conducted eighteen consumer seminars a part of the Project Sunshine series. Total attendance was approximately 2,000 for these programs which were offered free of charge. The primary purpose of these seminars was to tell the interested public how a solar water heater works, what it costs, how to shop wisely for one, and generally to convince them solar can be a good investment. Additionally, the topics of solar swimming pool heating, residential conservation, and passive building design in hot humid climates were discussed.

Promotion of the consumer seminars was accomplished by news releases, radio announcements, brochures, flyers, notices in the leisure sections of newspapers, and paid advertisements in newspapers. Considerable cooperation in these endeavors was received from county extension offices, educational insitutions, local governments, and local radio stations. The seminars were usually offered in the evening at conveniently located community colleges and high schools. Attendance at the first offering approached 150, but attendance at the next five was much lower (ranging from 50 to 6). A change in promotional methods corrected the low attendance problem when the seminars were subsequently conducted in Central Florida and in Jacksonville. For these seminars, the public was invited using two-column by six-inch paid newspaper announcements. Except for Lakeland, which attracted only 50 people, attendance in Central Florida varied between 150 and 250. Attendance for the two Jacksonville seminars was 300 (August 1980) and 150 (September 1980).

The format for the 90-minute to 2-hour programs included a slide presentation, questions and answers, and exhibits by members of the solar industry. Attendees registered by zip code so that potential market areas could be identified. They were also asked to fill out short, 4-question evaluation sheets at the end of the programs.

5.1 Consumer Seminars — Conclusions

1. Attendees overwhelmingly felt that they were in a better position to shop wisely for a solar system (96 percent of respondents) after attending the seminar.
2. Attendees overwhelmingly said they would inquire further about a solar system for their family's use (85 percent of respondents) after attending the seminar.
3. Overwhelmingly, the attendees were convinced that solar devices make good good sense for Floridians (97 percent of respondents) after attending the seminar.
4. The best attended seminars were promoted primarily by attractive newspaper advertisements, which listed the speaker's name, credentials, and specific topic areas.
5. The poorly attended seminars relied primarily on news releases and radio announcements. (The radio announcements were sometimes incomplete and sometimes inaccurate).
6. Insufficient lead time for advanced planning and promotion were responsible for the poor attendance at several of the South Florida seminars.
7. Seminar locations in South Florida could have been arranged to better serve the three major cities (West Palm Beach, Ft. Lauderdale, and Miami). Dates for these seminars should also have been better spaced, rather than concentrated into about a two-week time period.
8. Cooperative extension agents can be extremely helpful in promoting local seminars and workshops.
9. Industry exhibits added greatly to the value of the seminars by complementing the slide presentation with hardware and the expertise of the exhibitors.
10. Effective advertising and aggressive promotion are the keys to successful attendance figures for public seminars.

6.0 Newspaper Articles

Six articles on solar domestic hot water and pool heating systems were prepared by FSEC and distributed to 64 Florida newspapers. These articles were prepared in a news release format with attached illustrations. The fact that a total of four articles were published by only two newspapers was discouraging.

6.1 Newspaper Articles — Conclusions

1. Efforts to get broad spectrum information about solar energy to the public through the six newspaper articles were unsuccessful.
2. Publication of the articles might have been more widespread if more illustrations had been used. (It should be noted, however, that the illustrations that were distributed were of excellent quality.)
3. Publication of the articles might have been more widespread if they had been delivered to the newspaper in camera-ready format, rather than in a news release format. (Variation in format from one newspaper to another was the reason for choosing the news release format.)

7.0 Other Media Efforts

Four radio talk shows were arranged by FSEC for SSEC with stations WINZ (Miami), WPBR (West Palm Beach), WEAT (West Palm Beach) and WKAT (Miami Beach). Because of good broadcast times, total audience size was estimated in the tens of thousands.

A seminar specifically designed for members of the news media was presented on October 15, 1979, from 7 p.m. to 9 p.m. in Ft. Lauderdale. Only a few members of the news media were also invited to be luncheon guests of FSEC at a November 8, 1979, U.S. Department of Energy sponsored workshop for the financial community at Singer Island (near West Palm Beach). The luncheon presentation described Project Sunshine. Once again, only a few members of the news media responded to the invitation. However, media coverage of the financial workshop was excellent.

7.1 Other Media Efforts — Conclusions

The radio talk shows were a successful part of the powerful campaign, but, because of poor attendance, the media seminars were evaluated as unsuccessful.

8.0 Summary

The consumer seminars were well attended, informative and received excellent evaluations. The dissemination of information, using the solar information brochures and the more detailed consumer guides, exceeded expectations, both in terms of the number distributed and the favorable response. The three installation short courses involved much effort and received high marks from the industry participants. The six newspaper articles, which were offered to over 60 Florida newspapers, were not published as anticipated, possibly due to the news release format which was used. Of all other efforts to utilize the mass media, the radio talk shows appeared to be the most successful.

In summary, Project Sunshine was a unique educational program, both in terms of the scope of techniques utilized, and the various organizations involved. Hopefully, the information presented here will prove useful to others involved with the important responsibility for energy education.

2.6

EDUCATING THE PUBLIC THROUGH A DESIGN COURSE

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Abstract

The course in Solar Design at Washington State University provides an opportunity to educate persons outside, as well as inside, the classroom. The course meets three needs: (1) a course in design is required of graduating seniors, (2) engineering students wish to design "real world" objects, and (3) the general public needs specific energy-saving information. The course objectives include for the student an integration of learning, work on a practical project, and communication.

Following an initial contact with the building owner by the instructor, an assigned team of two students visits the building and obtains from the owner physical data on the building and on its several energy consumptions. The team then designs a solar energy system which could be retrofitted to the building and which would be as cost-effective and as energy savings-effective as possible. A project display board showing a perspective drawing of the building and performance data of the solar system is also produced by the team. In a three year period, residential, commercial, and institutional buildings have been treated.

The building owner learns from his involvement. He furnishes data on his building, receives progress reports from the team, and often discusses various questions about his building with them. He also receives a copy of the team's final report with its recommendations. All owners are invited to attend the final presentation at which all of the student teams describe their work and answer questions. The project display boards which contain perspective drawings of the buildings and show performance data of the solar systems are placed on public display. This means of publicizing solar energy usage has been provided by the local electric utility company, which has displayed the boards in their main and branch offices in this region.

Introduction

As a result of the general concern about energy, university students, and the general public, have become increasingly interested in methods of energy conservation. This includes the use of alternate sources. At Washington State University a design course in solar energy has been developed. Its aim is to educate the public as well as the students through the use of solar projects using existing buildings. The purpose of this paper is to describe this design course and how it educates both the public and students.

The Initial Situation

Senior mechanical engineering students must take a design course as a requirement for graduation. The course usually involves decision-making actions and a determination of the performance of the device that is designed. Concering the public, our contacts indicate a genuine interest in saving energy and a large ingnorance of the technical factors involved in energy conservation. The solar resource in eastern Washington may be classed as poor. The available annual global sunshine in the Pullman area is approximately 50% of that in the prime areas of the United States.

Objectives
The three principal objectives of the course are: (1) To integrate in the senior year the student's learning experiences from other courses. (2) To provide the student with an opportunity to work on, and complete a "real world" project of some length. (3) To communicate the results of the study to people outside of the classroom.

Methodology
A guided design experience is provided for the students in this one-semester, three-credit course. The students are assigned the problem of designing a suitable energy-saving solar heating system for a building and reporting the work in verbal, written, and poster form.

Local buildings are used as study subjects because they are structurally simple, easily accessible, and real (not merely drawings or models). Residential, commercial, and institutional building types provide a wide variety of heating requirements and heating systems.

Each student team, two persons, is responsible for gathering is own data on building dimensions and energy usage. This necessitates one or more contacts with the owner or manager. Such contacts serve to acquaint the owner/manager with important energy saving concepts, and to develop a cooperative attitude between him/her and the team.

Action by the Instructor
Before the course begins, the instructor arranges for the use of the buildings. The offer is for a project to learn the energy-saving and dollar-saving potential of a solar heating system, at no cost to the owner. For institutional and commercial buildings the building manager is contacted. Residential buildings are found from responses to an advertisement in the local newspaper. The instructor visits each building to determine its adequacy of solar exposure. With all types of buildings a following letter confirms the selection and lists the types of information the students may need.

During a class meeting the instructor introduces the project, states the course objectives, forms the teams, and gives written instructions on certain items of form and procedure. Also, the students are given letters of introduction to the building owners for identification purposes.

In regular weekly class sessions the instructor lectures on appropriate methods of analysis and design techniques, receives verbal progress reports and questions from each team, and makes announcements of new solar developments and current items in the solar industry.

Student Work
The class also meets twice a week for three-hour lab sessions. Each team is responsible for its own design and results as it works through the steps outlined below.

Each team calculates the heat load and determines the heat requirements of its own building. To date, the degree-day method described by ASHRAE (1) has been used. These are compared with records of metered usage or fuel billings when available. The next step is to produce the conceptual design of a solar heating system for the building. This takes into account the heat load, owner preferences, appearance, and cost. Recommendations for futher weather-proofing of the building are made at this stage due to its greater cost effectiveness than the purchase of new heating equipment.

Each team determines the sizing of solar components. The goal at this step is the definition of a maximum sized solar system and its interface with the existing heating system. Component locations are made considering solar exposure, appearance, and service accessibility.

The student teams estimate the cost of the solar system using the current Means Construction Cost Data (2) and manufacturers' literature. Thermal and financial performance of the designed system are determined by the FCHART (3) computer program for active systems and by the Passive Solar Design Handbook (4) for passive systems.

As the semester draws toward a close the teams complete their preparations of the three required reports. Verbal presentations with visuals are made at a public meeting attended by building owners, utility representatives, contractors, and city government personnel. Written reports of an "engineer-to-client" type are prepared for distribution to building owners, the instructor, the Engineering Extension office, and the local utility company. Each team also produces a large poster which describes its solar design. The poster presents a sketch showing the solar collector on the building in perspective view, a system schematic diagram, and an energy and financial performance summary.

Educational Results
This course fulfills the objectives. The students find many practical applications of the principles they learned in previous courses, primarily thermodynamics, fluid mechanics, and heat transfer. This single project, requiring early decisions which affect later results, involves analysis of energy needs, synthesis of system design, and prediction of system performance on a real building. The project results are communicated to several components of the public. A summary of student enrollment and project completion is shown in Table 1.

TABLE I TALLY OF ENROLLMENT AND PROJECTS

YEAR	No. of STUDENTS	No. of PROJECTS
1978	17	6
1979	17	7
1980 (two semesters)	48	23
1981	20	10
	102	46

The enrolled students are, of course, the primary recipients of public education through this course. They go out into the business world with a first-hand experience in designing a solar heating system for a real building.

The building onwers/managers also receive some education. With their personal or business interest in the building they are keenly aware that project information can directly affect their future operating costs. Following the instructor's initial letter the owners receive several visits by the team to acquire building energy data, three written progress reports, a verbal description of the work at the public meeting, and a copy of the team's final written report which includes recommendations. Thus, the owners learn from their involvement with the project at various stages.

Personnel from the commercial and city government sectors of the public learn from the projects in two ways. First, by contacts with the students as they seek information and suggestions on certain details of their designs. Electrical and plumbing code regulations, zoning ordinances, and general construction practices are frequent subjects of student inquiries to the utility company, to contractors, and to city government officials. These outside persons are invited to attend the public presentation of the projects. This is a second opportunity for them to learn about the utilization of solar energy from this design course.

The general public sees applications of solar energy to real buildings pictured on the student-made display boards. These are regularly shown in the numerous local offices of the utility company, at energy fairs, and at university open house events.
Many positive responses to the course have been received.

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Acknowledgements

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2.7

INFORMATION AND EDUCATION PROGRAM AT NEW MEXICO SOLAR ENERGY INSTITUTE

by
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Abstract

The Information and Education (I&E) Division of the New Mexico Solar Energy Institute (NMSEI) conducts outreach programs on a wide variety of fronts. Technical and non-technical workshops, seminars and training courses are conducted; publications (including brochures, fact sheets, technical and non-technical reports) are produced and distributed; exhibits and displays are staged at major functions within and outside the state; audio-visual materials are produced (including slide-tape and video programs); and a variety of in-house services are provided for the technical staff of NMSEI.

Recent and current I&E projects of interest include the Solar Upgrading of Low-Income Housing Demonstrations Project, during which many people were trained and educated in solar retrofitting techniques and over 230 solar retrofits were installed; the production (in conjunction with other university departments) of five basic video programs (each half an hour long) describing the uses of solar energy for space and hot water heating, which have been aired on over 100 TV stations across the nation and in Canada; the equipping of three visitor centers (at large photovoltaic installations) with audio-visual and graphic materials and publications; and the conduction of numerous technical and non-technical workshops and training courses.

In this paper, the above activities are discussed in detail, and the problems and experiences of an education and outreach program which is partly state-supported will be discussed. Future plans (bearing in mind the expected cut-backs in federal funding levels) are outlined.

Introduction

In July 1977, the New Mexico Solar Energy Institute (NMSEI) was founded at New Mexico State University (NMSU), with legislative directives aimed at promoting the use of solar energy in the state of New Mexico. While NMSEI pursues research, development, and demonstration work in the fields of solar heating and cooling, photovoltaics, wind, and bioenergy, one of the legislative mandates of NMSEI concerns the dissemination of information about solar energy to New Mexico citizens and to industry in the state. In keeping with this mandate, a division of Information and Education (I&E) was established as one of the three original divisions of NMSEI. The I&E activities of NMSEI are described in detail below.

Workshops and Training Courses

Workshops and training courses are conducted on an average rate of two to three per month. One of the most popular workshops, which is conducted about six to eight times per year, is a general overview of Residential Uses of Solar Energy. This one-day workshop is aimed at the general public, and gives basic information on the ways in which different systems work, and their advantages and disadvantages. The following topics are covered: Energy Conscious Design, Passive Heating and Cooling Systems, Active Heating and Cooling

Systems, Passive and Active Hot Water Systems, Photovoltaics, Wind Energy, Economics of Solar Systems, and Tax Incentives. Average attendance at this workshop is usually about 75 to 100 people in larger towns and cities and about 30 to 50 in the less populated areas.

A one-day workshop on Solar Domestic Hot Water Systems has also proven extremely popular. Under a contract received from Western SUN, a 218 page manual was developed and three initial workshops were conducted; an additional five workshops have subsequently been staged. Attendance has exceeded 70 people at six of these workshops. Despite the fact that the workshop was originally aimed at contractors and installers, many members of the general public have attended.

NMSEI has also conducted a number of "hands-on" construction workshops and training courses. Workshops have been conducted at which members of the general public have assembled collectors (from a kit supplied by a local manufacturer) and purchased the necessary hardware to install a draindown solar hot water heater on their house. Instruction is given during the workshop in the operation of installation of the system, and various plumbing and electrical techniques are demonstrated. "Hands-on" training courses in the construction of batch water heaters have also been conducted.

Technical workshops on the design of passive systems are presented from time to time for architects, designers, contractors, and owner-builders. Other target audiences for whom workshops have been staged include realtors, appraisers, teachers, agriculturalists, and financiers. One-day workshops on the use of wind energy and photovoltaics have also been conducted.

Publications
The I&E Division of NMSEI produces two basic series of publications. Brochures in the Solar Educational Series are aimed at providing a fundamental explanation of how various solar systems work. There are currently four titles available in this series: Passive Solar Space Heating Systems, Passive Domestic Hot Water Systems, Active Solar Space Heating and Cooling Systems, and Active Domestic Hot Water Systems. Additional titles currently being developed include Photovoltaics, Wind Energy, and Bioenergy.

A series of low-cost fact sheets is also produced, to give more detailed information on particular systems and applications, e.g., Breadbox Hot Water Heaters, Draindown Hot Water Systems, Themosypohon Hot Water Systems, various passive applications, Alcohol Fuels, etc. In addition, fact sheets are produced on non-technical issues — Solar Rights, Economics, Tax Credits, etc.
Other publications which are produced include a Directory of New Mexico Solar Businesses, and regular editions of the NMSEI Activities Report. Manuals have been produced for use in workshops, and various technical reports arising out of contract and other work have been produced.

Information Services
NMSEI employs two Information Specialists who respond to requests for information by telephone, letter, and in person. These staff members also coordinate and arrange all workshop activities. An average of about 300 requests for information are received each month; technical inquiries are referred to staff members in the technical divisions. NMSEI also maintains a reading/resource room, which is open to the general public, and which is continuously updated with the latest books, periodicals, and reports.

Exhibits are set up and manned at various fairs, conventions, and exhibitions throughout the year. The largest of these is the New Mexico State Fair at which over 5,000 people annually visit the NMSEI exhibit. Working displays include active and passive solar hot water systems, photovoltaic-operated pumps, models of passive houses, and wind machines.

Solar Upgrading of Low-Income Housing Demonstration Project
In September 1978, the Southwest Border Regional Commission contracted with NMSEI to administer a $400,000 demonstration program on the solar upgrading of low-income housing in the border regions of California, Arizona, New Mexico, and Texas. The major aim of this program was to develop and demonstrate solar technologies applicable to residences of low-income people in the border areas. Other aims were to train local people in design, installation and maintenance of appropriate solar applications and technologies and to stimulate economic development and business activity in solar fields.

This project has demonstrated a variety of appropriate low-cost solar applications and provided prototypes for regional low-income inhabitants. Space heating and cooling systems and water heating systems have been combined with weatherization and conservation techniques. A total of 237 retrofits were installed, including 180 solar hot water systems of different kinds — 59 of the simple "batch" or "breadbox" type, 81 thermosiphon systems, 35 active liquid systems, and 2 active air systems. Solar space heating systems completed include 12 Trombe walls, 5 convective loop window units, and 3 thermal storage walls using drums of water for storage. Retrofits to help cool houses in the hot summer months included 30 attic venting systems (both active and passive) and the creation of 7 vine canopies to shade the walls and roofs of the houses.

"Basic Solar Energy" TV Series
A five-part television series on basic uses of solar energy for space and water heating has been produced in conjunction with two other departments at NMSU — the department of Educational Management and Development and the local public television station on campus (KRWG-TV). This series consists of half-hour units on Energy Conscious Design, Passive Solar Systems, Active Air Systems, Active Liquid Systems, and Retrofitting Solar to Existing Buildings. NMSEI staff serves as consultants, organized on-location taping, scripted the units, provided technical continuity, and narrated the series.

The series has now aired on over 100 PBS stations across the USA and in Canada. The programs have been accepted for satellite distribution by the Pacific Mountain Network regional subdivision of the Public Broadcasting Service. All PBS stations in the U.S. now have access to the programs. Copies of the tapes have been ordered by the International Communication Agency for use in South America.

Other Contract Activities
Other contract activities include the equipping of four visitor centers with informational material and displays. Three of these centers are located at large photovoltaic facilities which have been (or are being) installed under federal contract; the other is at the site of a concentrating collector array to generate steam for use at an oil refinery in New Mexico. Material being prepared includes automated slide-tape shows, informational brochures, and pamphlets, and graphic displays.

Work has recently commenced on three contracts funded by Western SUN. Arising out of these contracts, three publications will be produced and distributed in New Mexico. An easy-to-use Access Guide to Renewable Energy in New Mexico will be produced, to aid the media in coverge of New Mexico renewable energy activities. A survey of Institutional Hot Water Applications in New Mexico will document non-residential solar hot water systems in the state, and describe the successes and problems encountered. A Solar Housing Catalog is also being produced to provide information on appropriate solar applications for local housing projects, housing development corporations, and individuals involved in public and federally subsidized housing.

In-House Services

The I&E Division provides a variety of in-house services to the other technical divisions and to the director's office. These include the provision of graphic services (illustrations, displays, original art for publications, posters, maps, charts, etc.) and audio-visual materials (e.g., slides, photographs, transparencies, tape recordings, slide-tape shows). Assistance is given in the preparation of technical notes, publications, and reports with regard to design and layout, paste-up, and production. Statewide surveys are conducted to identify prospective partners for proposals or projects, and mailing lists are compiled and updated in conjunction with the secretarial staff of NMSEI. Literature searches and services on information retrieval are provided for technical personnel of NMSEI. Publicity for all NMSEI projects is handled by the I&E Division, and a quarterly newsletter describing the activites of NMSEI is published.

Since the inception of NMSEI, the provision of in-house services has gradually taken more and more time and effort. This is due mainly to the increased level of activity in most of the technical divisions, and to the fact that adequate funds for publicity, photographic, and graphic services are sometimes not written into propsals. In order to continue a reasonable level of activity in the field of Information and Education, in-house services in some of the areas described above have had to be limited.

Future Activities

Since the majority of the I&E division's work is state-funded, cutbacks in federal funding are not expected to have a marked effect. An increased level of funding for in-state outreach work will be sought, and the workshop, publication, and information services programs will be expanded if this increase is obtained. Technical workshops in photovoltaics and wind energy are planned (in conjunction with technical divisions of NMSEI) — these should be at least self-supporting. NMSEI work in low-cost appropriate solar technologies is becoming known, and self-supporting training courses and workshops in these areas are being planned, both inside and outside New Mexico. Audio-visual training materials (e.g. slide-tape shows) are being prepated for sale. Based on the wide experience which has been obtained in the past few years, NMSEI intends to actively and aggressively expand its activities in out-of-state and overseas contract work.

2.8

AN INTERDISCIPLINARY COURSE ON SOLAR HOME DESIGN

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Abstract

An experimental one-quarter interdisciplinary course in energy-efficient home design has been developed and taught at Iowa State University. The course is cross-listed between the Departments of Architecture and of Physics, with different requirements of the students receiving each type of credit. The instructors are a practicing architectect with a distinguished record in residential solar architecture and a research physicist in the field of solar energy who lives in an award-winning passive solar home on which the two instructors collaborated.

Background

In Iowa and nearby states, space heating accounts for a majority of the total energy used in homes. Conventional Iowa homes for which no energy conservation improvements have been made can easily require two to four times as much energy for space heating as for all other energy uses combined.

With the use of good energy conservation techniques (such as insulation, weatherstripping, and so forth) and passive solar heating concepts, the energy consumption for space heating can be reduced by a factor of 2 or 3 for existing homes and 10 or more for new homes. This leads to large energy and economic savings and can make the cost of space heating negligible in cold climates.

As an example, the first author moved into an older home in 1970 that required about 7400 m^3 (2600 CCF) of natural gas to heat in the fairly average winter of 1970-71. By 1978-79, this had been reduced to 4800 m^3 (1700 CCF) in a much colder winter (4368 C° -days) through a variety of energy conservation techniques. In 1980-81, his family required only 360 m^3 (128 CCF) of natural gas for space heating in a new energy-efficient passive solar home, an impressively small amount (about $45 worth) even for a mild winter (3285 C° -days).

The Hodges Residence, Iowa's first scientifically-designed earth-sheltered passive solar home and a winner in the 1978 National Passive Solar Residential Design Competition sponsored by the U.S. Departments of Housing and Urban Development and of Energy, was designed by the second author with assistance in the solar design from the first author. Our collaboration on this project and on several passive solar energy articles and research projects led naturally to the consideration of developing a university course on energy-efficient home design.

Architecture/Physics 351X

Iowa State University has always operated on a quarter system, so the new experimental course needed to be a course lasting one quarter. We wanted to reach students sufficiently advanced to be able to produce fairly sophisticated designs, so we limited enrollment to upper-class students with adequate preparation.

Since our previous collaborative efforts had been aided by the matching of our complementary experiences as an architect and a physicist, we felt the course would prove most beneficial to students if they could be similarly matched.

For that reason, we proposed to the relevant curriculum committees a course that would be cross-listed between the Architecture and Physics departments, with the same course number, but with different types of students. The course number, 351X, denoted a 300 (junior-level) course of an experimental (X) nature. Students taking Architecture 351X were required to have a background in design equivalent to about two years as an architecture major. Students taking Physics 351X were required to have taken the introductory three-quarter sequence in classical physics with calculus.

The students were paired into teams of one Architecture and one Physics student. Each team was expected to design an energy-efficient home for an assigned hypothetical client on an assigned real site, and carry out energy performance calcula-for the home in the climate of central Iowa. Although both team members attended the same lectures, worked many of the same assigned numerical problems, and collaborated on the design of the home, the Architecture student had primary responsibility for the architectural design and drawings, while the Physics student had primary responsibility for the calculations and solar system details. This justified giving one student Architecture credit and the other Physics credit.

Organization of the Course

As a quarter has only 10 weeks of teaching, time was really too short for what we wanted to accomplish. We gave the students 3 hours credit but met twice a week for two consecutive hours.

In the first six weeks we had lectues taught by one or the other of the instructors. The topics covered by the Architecture instructor included:

Procedures to use in designing a house for known clients on a known site
The design and operation of active solar systems (in which he had previous experience)
Examples of several real projects (including the Hodges Residence)

The topics covered by the Physics instructor included:

Principles of energy conservation and solar energy
Heat loss calculations for buildings
Thermal performance of buildings, including solar performance

In addition, considerable time was spent on joint lectures dealing with passive solar heating and natural cooling concepts and their incorporation into residential design.

The seventh week each time the course was taught coincided with a National Solar Design Workshop held on the Iowa State University campus under the direction of Professor Eino Kainlauri of Architecture Extension. The course did not meet that week, but students were urged to listen to as many of the speakers as possible and to assist in the individual design workshops held at the conference.

The eighth and ninth weeks were devoted to studio time. The instructors met with the student teams to answer questions and suggest improvements in the designs.

The tenth week of the course and part of Final Exam Week were devoted to the team presentations and critiques. Each team typically took about 15 minuted to present an analysis of its clients and assigned site, the design of the home, and the energy performance of the structure, and another 15 minutes or so were devoted to critique by the instructors and by the other students in the course.

The presentation requirements included: (1) a site plan showing the house, driveways, landscaping, and so forth; (2) floor plans showing rooms, furniture, major appliances, stairs, walls, window locations, and so forth; (3) north, east, south and west elevations of the house; (4) one or more sections of the house showing the operation of the solar and natural cooling systems; (5) an exterior perspective of the house (with interior perspective optional); (6) heat loss calculations for the house; (7) solar thermal performance calculations.

As no suitable textbook exists for such a course, we required none. We listed some valuable reference books which we urged the students to purchase for their personal libraries. Among the recommended books which many students found useful were Bruce Anderson's *The Solar Home Book*, Edward Mazria's *The Passive Solar Energy Book*, David Wright's *Natural Solar Architecture*, James McCullagh's *The Solar Greenhouse Book*, Don Watson's *Designing and Building a Solar House*, and the University of Minnesota Underground Space Center's *Earth Sheltered Housing Design*.

Numerous other materials in the instructors' libraries were made available for students to use. These included, most notably, the Proceedings of the annual National Passive Solar Conferences, published by the American Section of the International Solar Energy Society at the University of Delaware.

In addition, many locally-prepared materials were distributed in the forms of notes and workbooks. These covered such topics as

The relation between clock time and solar time
Determination of the sun's altitude and azimuth at arbitrary times at any location
Meteorological and climatological information such as temperatures, insolation, wind speed and direction
Methods to predict solar radiation falling on surfaces at any arbitrary tilt and orientation, based on meausred insolation on horizontal surfaces
Heat loss calculations for buildings
Rules of thumb for passive solar systems
Solar performance calculations for buildings
Simple economic calculation methods
Numerical problems dealing with all the topics above, some assigned to all students and some only to Physics students

In addition, several useful computer programs developed by the first author were made available to interested students.

Results

This course was taught three times, in the Spring Quarters of 1979, 1980 and 1981. Despite minimal "advertising" of this experimental course, many students asked to enroll in it. We decided to restrict enrollment to ten to twelve teams and had no difficulty reaching this number with qualified students. Most of the Architecture students were junior- or senior-level architecture majors, but a few had other design majors. Most of the Physics students were engineering majors, with a few physics majors. Several graduate students in Architecture were admitted as one-person teams and given graduate-leve credit in the Architecture department.

The students generally emjoyed the course, attending regularly, working hard on their designs, doing extra work in some cases, and often consulting with the instructors outside of regular class hours. Several students commented on the value of having architects collaborate with engineers or physicists, apparently because it helped the students appreciate the ideals and techniques of the other profession.

A few teams were formed by the students themselves, but most were assigned randomly at the beginning of the course. In general this worked out satisfactorily. The contributions of each team member were very clear because of the considerable personal interaction between instructors and students. As a result, the members of a team sometimes received the same grade but generally did not; in one extreme case, one team member received an A while his partner received a D.

One problem that occurred with a few teams resulted from the pairing of an architecture major accustomed to doing most of his or her work just before a deadline with an engineer who preferred a more steady pace of work. In two instances this led to serious difficulties requiring the instructors' help.

A major problem with the experimental course was the brevity of the quarter. Ten weeks is not adequate time to teach the prinicplies of energy-efficient design and yet permit the student teams to design a home. The teams had to begin working on their designs before all the principles had been adequately taught.

Future Changes

Fortunately, Iowa State University will begin using the semester system in the 1981-82 academic year. The Architecture and Physics departments have approved the listing of this course, with the title "Energy Analysis of Residential Structures," in the 1981-83 catalog of university courses. Because of junior-level reqrequisites for Architecture students and the previous reqrequisites for Physics students, the course is listed as Architecture 468 and Physics 351.

The course will be substantially improved as a semester course. With 15 weeks, it will be possible to have 10 weeks of lectures and cover the subject more thoroughly, while allowing the students to have much more time on their projects. More problems will be assigned and a comprehensive workbook developed. There will be a firmer schedule with some intermediate deadlines on various aspects of the home designs, to speed up the procrastinators. Every student will be expected to learn to use some computer programs prepared for the course, and the Physics students will be assigned some programming problems.

Conclusion

As energy prices continue to rise and the public becomes more aware of the value of energy-efficient building design, courses such as ours should become increasingly important. While we stressed new single-family residential construction, the principles and calculation methods used are also applicable to multi-family dwellings, small commercial buildings, and the retrofit of existing buildings. We have found this course to be hard work, but the efforts are very rewarding to us as teachers, and the students who have taken the course seem quite pleased to find themselves at the frontier of knowledge, using information that has not yet found its way into textbooks.

2.9

SOLAR CELLS IN SCHOOL

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1. Introduction

In order to meet the increasing demand for the terrestrial use of solar cells for power generation a reduction of cell cost is required from that of the established silicon cell. The low material requirements, both in quantity and quality of the Cadmium Sulphide — Copper Sulphide ($CdS - Cu_2S$) cell, and the ability to deposit large areas of film make it an obvious contender in the race to mass produce cells at a cost of 50p per watt.

The process for fabricating a lightweight $CdS - Cu_2S$ solar cell was developed by workers at the Clevite Corporation in the U.S.A. and is summarised as follows. A metallized plastic.acts as a substrate for the vacuum deposition of thermally evaporated CdS layer approximately 25 "m thick. The surface of the n-type CdS layer is then converted to copper sulphide, nominally Cu_2S by immersion in an aqueous solution of Cu Cl. The cell is then completed by bonding to the Cu2 S a metalic grid to assist current collection, followed by a layer of plastic encapsulant. This is shown diagramatically in Figure 1.

The sixth form project aims to simplify this process by reducing the level of technology required and undertake some fundamental studies to develop an understanding of the device.

2. The CdS Layer

CdS films have been prepared by spray pyrolysis. Despite the great potential of this method for producing cheap cells for terrestrial applications very few attempts have been made by other workders to make cells in this way.

A schematic diagram of the spraying apparatus is shown in fig. 2 and is a modified paint spray available from most laboratory suppliers. Tin Oxide coated glass was used as a substrate as this forms an ohmic contact to cadmium sulphide. The substrate was floated on molten lead in order to increase its temperature. This improved the adhesion and structural quality of the films. The spray solution was a mixture of thiourea (which provides sulphur ions) and cadmium chloride (providing cadmium ions) in equal proportion by weight and dissolved in distilled water. These compunds react on the substrate to form cadmium sulphide. The spraying was carried out in 5-10 second intervals to allow the substrate to recover the temperature loss and re-attain its desired spraying temperature of 340° C. After spraying the films were baked in an inert atmosphere at 400° C for 30 minutes in order to increase the grain size.

Evaluation

The current-voltage characteristic of a typical film before plating is shown in fig. 3. The dark resistivity of such films was found to be 200 ''m falling to 1.39 ''m under standard illumination. These films were then examined under a microscope and found to have no obvious pin-holes. Film thickness (typically 20 ''m) was estimated by comparing the optical transmission of a given film against several of known thickness grown by the authors at the University of Durham and measured using interference microscopy techniques.

All films sprayed using the described method were found to exhibit green photoluminesce when excited with U-V light at 77K.

3. **The Cu_2S Layer**

In order to form the p-type Cu_2S on these layers a plating solution was prepared as follows:

(a) 750 ml of distilled water was heated and stirred in a closed reaction vessel while oxygen free nitrogen was continuously bubbled through to displace oxygen.

(b) 100 ml of hydrazine hydrate was added.

(c) a pH meter was used to measure the acidity of the solution which was accurately adjusted to pH 2.5 by adding drops of hydrochloric acid or hydrazine hydrate. (The nitrogen and hydrazine hydrate prevent the formation of Cu^{++} ions.)

(d) Next 10g of CuCl was added and the liquid volume made up to 1 litre by adding distilled water.

(e) The bath was heated to 90° C and the CdS layers etched in IN potassium iodide solution for 10 seconds before a similar period of plating. On removal from the bath the dark Cu_2S layer was clearly visible. This reaction is governed by the equation:

$$2CuCl + CdS \qquad CdCl_2 = Cu_2S$$

After plating, the cell was baked for 2 minutes in air at 200‡C. This baking causes Cu^+ ions to diffuse into the n-type CdS, thus compensating it and creating an insulating, protoconductive layer.

4. **Cell Performance**

The cell was illuminated through the glass, as this yielded higher efficiencies and precluded the need for a grid contact to the Cu_2S/a simple plaint contact sufficed. The current-voltage characteristic of the final cell is shown in fig. 4. The cell gave an open current voltage of 390 mv and a short circuit current of 0.8 mA. This corresponds to an overall efficiency of 2%. The cell showed no significant degradation when operated for a two hour period and six such cells feeding an hystersis motor were used to drive a model round-a-bout.

5. **Plating bath kinetics**

The transformation of CdS to Cu_2S takes place epitaxially and Singer and Faeth in 1970 and Cook et al in 1970 have reported the complete conversion of a single crystal of cadium sulphide to a cracked but single crystal of copper sulphide. The cracks are a direct result of the strain which is introduced by the mismatch between the lattices of the two sulphides.

In preparation of the solar cell the CdS film is dipped in the plating bath for a very short time (in the order of 10 seconds). However, in order to study the transformation process it is necessary to immerse the layer of cadmium sulphide in the plating bath for several hours. This was done and the formation of Cu_2S monitored by the increase in weight of the sample. A graph of the increase in weight of the sample against time is shown in fig. 5. Previous studies on the conversion process have produced conflicting results. Lindquist and Bube (1970) found that the thickness of the cuprous sulphide layer increased linearly with immersion time whereas Singer and Faeth (1971) and Sreedhar et al (1970) found that the rate of growth of the copper sulphide layer followed a parabolic law. The shape of fig. 5 indicated a linear relationship between the increase in mass of the sample and the square root of the plating time.

i.e. $\quad m \quad t^{1/2}$

This parabolic law is in agreement with some of the previous workers described on the previous page.

When the reaction

$$CdS + 2Cu^+ \qquad Cu_2S + Cd^{++}$$

is taken to the limit in the plating bath all the CdS is converted to Cu_2S. Since the molecular weight of CdS is 144.46 and Cu_2S 159.14 a complete conversion would lead to an increase in weight of 10.1%. The increase in weight of the sample shown in fig. 6 corresponds to 56% conversion of CdS to Cu_2S in 4 hours i.e. a Cu_2S layer 280 ''m thick. It is well known that the growth of oxide layers on metals follows a parabolic law (Pilling + Bedworth 1923) and this is taken as evidence that the rate of formation of the oxide layer is diffusion limited. In our case, this would imply that the rate-limiting step is the diffusion of cuprous ions through the cuprous sulphide. If the process was limited by a reaction at the CdS-Cu_2S interface a linear growth law should be observed.

6. **Copper Sulphide Stochiometry**

One of the difficulties with the CdS - Cu_2S cell in its present state of development is that there is a degradation of the power output when it is operated for long periods in poor vacuum at temperature in excess of 60° C. This effect has been attributed by Bogus and Mattes (1972) to the photoassisted oxidation of Cu_2S Cu_2 - ''S.

It is implicit in this argument that a non-stoichometric deficit of copper in the copper sulphide will lead to a decrease in the efficiency of the cell. Further Palz et al (1972) suggested that the slow deterioration could be overcome by ensuring good initial stochiometry of the Cu S However we are not aware of any attempts to achieve this end in any controllable manner.

Rickert and Mathieu (1970) in a theoretical investigation of the Cu - S system, showed that it should be possible to vary the stochiometric composition of a compound Cu_xS by changing its electropotential during chemi-plating. We have therefore studied a system in which it is possible to measure and control the potential at the reaction interface when the copper fulphide layer is formed on the CdS.

Cells were fabricated using the same plating both described in Section 3. Two electrodes were used to measure the potentials developed in the plating bath.

Pure copper was placed in the solution to act as a reference electrode while a platinum electrode was measured using a pH meter as a high resistance voltmeter. In the absence of an applied voltage, a potential of 21 mV (Cu_2S positive with respect to copper) was recorded. A variety of cells was then prepared by applying external potentials ranging from -150 to +500 mV to the platinum electrode. In all other ways the fabrication process was identical to that described in Section 3.

Figure 6 shows the variation in open circuit voltage of the cells against the applied potential. Optimum results were achieved with a plating potential of +100 mV.

Discussion

It is important to recall that copper sulphide exists in three different phases, namely chalocite (Cu_2S), djurleite (Cu[illegible]S) and digenite (Cu[illegible]S).

Now Palz et al (1972) using a destructive method of coulometric titration have been able to measure the stochiometry of films of Cu_xS formed on solar cells. They were able to show a plot of OCV of a solar cell as a function of the copper content of the sulphide layer i.e. as a function of x. If we compare the magnitudes of the open circuit voltages shown in fig. 6 with those of Palz et al (fig. 7) we conclude that x increases from 1.97 to 1.98 when the bias in the plating bath is increased from zero to +100 mV.

7. Conclusions and future work

Our preliminary studies lead us to believe that spray pyrolysis is a viable method for the fabrication of CdS Solar Cells. In order to develop the device further and increase our understanding of its underlying principles future work is planned along the following lines:

(1) To examine the variation of resistivity of CdS films with spraying time to determine if prolonged spraying increases the sulphur content of the films.

(2) To develop a method for measuring Hall voltages in CdS films to determine the source of any change in film resistivity.

(3) To develop an accurate method of measuring film thickness.

(4) To measure the short circuit current of cells as a function of temperature in an attempt to relate this to phase changes in the copper sulphide.

(5) To investigate the viability of organic solar cells as cheap photovoltaic converters. This work will be undertaken in co-operation with Shell Research Ltd.

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2.10

A CLOSE-LOOP-ITERATIVELY-INTERACTING PROCESS FOR MASS-COMMUNICATION OF SOLAR ENERGY

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Abstract

It has widely been accepted that our planet offers us a limited quantity of fossil-fuels and also that the present global resources are depleting at a rapid rate due to the persistent enhanced rate of energy consumption of the modern society to maintain a bare minimum level of standard.

There has been several projections as to how long these fossil-fuels can last us. An average of various estimates predicts 2200 A.D. as the upper limit for the petroleum and 2700 A.D. for the coal; the two major resources of energy at present. Once consumed there is no way of replenishing these reserves and there are no viable means in sight which could synthesize them back to use. This dictates an inevitable energy transition.

In the present investigation an estimate of the period of existence of various present energy sources is drawn according to present available extensive survey. The potential alternatives of energy sources and hierarchy of their effective utilization is described. On the basis of feasibility analysis of these alternative sources of energy, a case of solar — as a solution to present energy crisis is discussed next. Near term prospects of solar energy, hierarchy of effective utilization, economic feasibility analysis etc. are presented to supplement the text.

Such a transition would not be cheap or easy rightaway, but its benefits would far outweigh the cost and difficulties in the long run. To bring the above kind of transition, a reality, a close-loop-iteratively-interactive processes like adult-education-programme and technology-transfer for an unspecialized sector through a highly specialised sector; programmes such as teacher-training and vocational-technical from a highly specialized sector to a specilized sector and so on. Such a close-loop-iteractively-interactive process is expected to enchance the mass awareness into the field of energy and could meet the total spectrum of future requirement of energy in future.

2.11

SOLAR ENERGY EDUCATION THROUGH RESEARCH PARTICIPATION

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The Solar Energy Research Institute has been established and designed by the Department of Energy as the lead center for research in solar as an alternative energy resource. As such, it has undertaken many areas of work, including several nontraditional educational (or research participation) activities, with the objective to provide professional and educational opportunities and stimulation for well qualified students and for established and promising faculty in solar energy. In all programs, the research participant is assigned to a SERI project and works under the supervision of a SERI staff member.

The Undergraduate Intern Program, in its third year, is conducted to expose college level junior and senior students to the broad problems associated with the practical widespread utilization of solar energy, including technical, economic, environmental, legal, and social aspects.

The Graduate Intern Program, initiated in 1978, is conducted to provide students who have completed at least one full year of graduate study the chance to apply to work at the Institute in such areas as policy development and analysis, legal issues and planning, information provision, and other socio-economic areas.

The Visiting Faculty Programs, Summer and Sabbatical appointments, provide the opportunity for university and college faculty to engage in research, development, analysis, and applications; establish continuing relations with SERI staff; and develop a basis for continued solar related work at their own institution.

This paper will describe the educational philosophy underlying the development and implementation of these programs, and will look at the construct and conduct of each effort. It will also address the evaluation phases of the program, compare the results of each, and suggest several methods for program improvement.

SESSION 3: ISSUES FOR CURRICULUM DEVELOPMENT

3.1

A CURRICULUM DEVELOPMENT MODEL FOR ENERGY EDUCATION

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Abstract
Over the years, a variety of different curriculum development models have been used in science education that emanated from the beliefs and interests of the developers. The values inherent in such models have seldom been clearly delineated and this omission has created problems for those educators involved in the implementation of a curriculum. This paper examines three curriculum development models that have been identified in the literature. These models have been substantiated by conceptuatlizations of curriculum scholars, an historical perspective of the literature, in science curriculum studies, and in an empirical study undertaken by this author. From this information a curriculum development model is constructed which is suitable for energy education.

Text
The special function of curriculum development is to select and to organize the content so that the desired goals of the curriculum are most effectively achieved. It is during the developmental activities that the problem of translating the aims of the curriculum into content occurs when developers are required to make judgments about content priorities. Such problems have existed since education became a deliberate process, and due to the values and perspectives of the developer, have resulted in content and a curriculum design that is peculiar to the influence and beliefs of the developer. These differences in curriculum design have been recognized by Macdonald,[1] Hyman,[2] Eisner and Vallance,[3] and others.

Knowledge of the values inherent in a particular curriculum development model is important to educators. This kind of information enables the curriculum developers to use a model whose values are best suited to matching the subject matter with the needs and interests of the students. Similarly, it permits an educator to select a curriculum suitable for particular students.

The purpose of this paper is to examine curriculum development models that have been substantiated from:
(a) Conceptualizations of curriculum scholars.
(b) An historical perspective of science curriculum development.
(c) Evidence in science curriculum studies, and
(d) The findings obtained in an empirical study by this author.[4]
From this information, a curriculum development model for energy education will then be constructed.

Macdonald believes that it is not possible for developers to deal with the curriculum as a purely objective phenomenon and identifies three curriculum development models from evidence in the literature, in research studies, and from the field. His three "ideal types" of curriculum development model are known as: (1) Linear-Expert, (2) Circular-Consensus, and (3) Dialogical, which are related to the cognitive human interests of control, consensus, and emancipation. These human interests are reflected in the following outlines of his models:
1. The Linear-Expert model is based on the basic human interest of control. The developmental procedures in this model are dominated by experts who attempt to maximize control by the discipline. The whole process therefore is controlled and monitored with specific goals in mind, and it is the experts who make the initial and final decisions about the validity of the content and organization of the curriculum. The nationally developed science curricula produced in the U.S.A. during the 1960's are examples of discipline-controlled curriculum development. These projects were initiated by discipline scholars at the university level who prepared the materials and tried them out in the classroom; then rewrote, piloted, and finally revised the curriculum materials for broad distribution. In this manner, the discipline scholar controlled the development of the curriculum, and thereby maintained the integrity of the discipline.

2. The Circular-Consensus model is based upon the basic human interests of consensus. This model is commonly referred to as the "grass roots" approach to curriculum development since it involves teachers, school administrators, laymen representative of the community, with experts on call if needed. All members of this group are regarded as being of equal rank in the deliberation process. In this model, there is a conviction that teachers must participate in the process of curriculum development, particularly if the materials which emanate from this process are to be properly used in the classroom. It is recognized that there is some rhetoric of control in the developmental processes of this model but consensus and communication should result in a worthwhile curriculum.

3. The Dialogical model is based upon the emerging needs of the student. Initially, teachers enter into dialogue with students to identify and determine the needs of the student population for whom the curriculum is intended. The adults then attempt to match the known cultural resources with the expressed needs and interests of the students. In this manner, the model actively involves the student in curriculum development, with the needs and interests of the students being given priority over the social and discipline content of the curriculum.

The description of Macdonald's three curriculum development models clearly indicate the value position and orientation inherent in each model. These orientations are supported by the following conceptualizations of curriculum scholars.

1. Support for the Linear-Expert model can be found in the work of Phenix,[5] and King and Brownell,[6] whose propositions for curriculum development consider only the knowledge found in the disciplines is suitable for a school's curriculum. Their argument is that since the discipline shcolars have an intimate knowledge of the disciplines they should control the process of curriculum development. Phenix viewed the discipline as a "conceptual system whose office is to gather a large number of cognitive elements into a common framework of

ideas."[7] The systematic categorization found in the discipline renders the profusion of cognitive ideas intelligible, and thereby serves as a valuable resource of materials for curriculum development. An understanding of the categorization of knowledge found in the disciplines allows the scholars to make intelligent decisions in the selection and organization of the content that:
(a) Is drawn entirely from the fields of disciplined knowledge.
(b) Is particularly representative of the field as a whole.
(c) Exemplifies the methods of inquiry and modes of understanding.
(d) Arouses the imagination.
These principles reveal Phenix's concern that only authenticated discipline knowledge should be in a curriculum.

The second discipline-oriented proposition is by Kind and Brownell. These curriculum conceptualists are in agreement with Phenix regarding the academic competence of an educator requirèd to select content for a curriculum. Furthermore, they consider that the discipline in its responsibility for passing on such knowledge to the young. To maintain the true nature of the discipline the curriculum must be an epitome of the discipline in every respect.

The human interests reflected in both of these conceptions of a curriculum are discipline oriented. This orientation considers that the most powerful products of man's intelligence are to be found in the academic disciplines, and the school's curriculum is the medium through which students can acquire this knowledge. It is, therefore, necessary that discipline scholars control the development of a curriculum.

2. Support for the Circular-Consensus model can be seen in the propositions made by Schwab,[8] and Walker.[9] Schwab considers that although the knowledge of the disciplines possessed by the scholars makes them indispensable for the task of curriculum development, their lack of knowledge in four other areas prevents them from being the sole arbiter. The other areas are concerned with knowledge of the learner, the milieu, the teachers, and the curriculum. These four areas must be represented and the curriculum developed in collaboration. Each member of the group should recognize the concerns, values, and operations of the others, and seek agreement among themselves in the judgmental factors in curriculum development.

Walker is in agreement with Schwab, and considers the group processes will ultimately arrive at a body of educational alternatives from which choices must be made. Such choices will not entirely satisfy the consensus and values of any one participant, but will satisfy the collective group more than does any other constellation of educational means.

3. Support for the Dialogical model can be found in the humanistic conceptions of curriculum development proposed by Sergiovanni and Starratt.[10] The main focus of their conception is with the selection of content which encourages man's personal and interpersonal development. They consider that curricular programs should be developed so that students can grapple with contemporary problems in a personally meaningful way. Activities of this nature should enable students to continually seek for the human significance of what he learns in the realm of knowledge. It is therefore necessary to develop a curriculum which incorporates the pressing problems of the day, and which is committed to the individual's personal development.

Similarly, Weinstein and Fantini[11] constructed a model for developing a curriculum of affect. The content of their curriculum would be personally meaningful and relate cognition to the learner's concerns for himself and for others. In this respect, the curriculum would enable the student to live harmonisouly within the biosphere.

An historical perspective of science curriculum development reveals that over the years many factors have influenced the selection and organization of content for a school's curriculum. During the latter half of the nineteenth century, colleges such as Harvard became a major influence over the selection and organization of content for high school science curricula which simply became college preparatory courses.[12] However, according to Underhill, [13] the changing socio-economic condition was the major influence. Developments in the fields of science and technology also made an impact on the steady growth of natural science curricula offered by the schools. These "new" curricula attempted to meet the social needs of a growing technological society thus emphasis was placed on content that was useful in the marketplace. Also, when concern was expressed at the turn of the century that many students could not benefit from the school's curricula a general science course was developed that would: appeal to students' interests, needs, and environmental experiences.

As the influence of the colleges over high school science curricula waned the teachers assumed a greater responsibility for developing courses which was maintained until the late 1950's when discipline scholars again undertook a dominant role in curriculum development.[14] A study undertaken by this author to examine the changes occurring in science curricula during the past one-hundred years revealed alterations in content that were in line with the expressed concerns of the times. Thus, curricula were developed which were utilitarian in nature for the benefit of society, or patterned after college science courses for those students who were college bound. Other courses of a general nature were provided to meet the needs of those students who did not wish to continue in higher studies but who were interested in learning science.

Science curriculum research undertaken during this period reflects a similar pattern to the changing socio-economic and science-technological developments. Many of these studies surveyed the needs and interests of the students in science in order to construct a suitable curriculum. In this manner, the studies provide credibility for the Dialogical model. Other studies were concerned with the relevancy of curriculum content for particular environmental regions thereby supporting the societal concerns of the Circular-Consensus model. A number of science curriculum studies were concerned solely with the involvement of discipline scholars to produce an authenticated science curriculum, and in so doing, gave credence to the Linear-Expert model. It may be assumed that when laymen, teachers, university professors, or high school students were involved in the studies it was in response to expressed needs. These needs were usually stated by professional organizations for functional science in society, general science for the individual's development, or discipline content to prepare students for higher learning. The numerous studies in science curriculum development that dealt with discipline, societal, or humanistic concerns give support to Macdonald's three curriculum development models.

An empirical study undertaken by this author was based on Macdonald's description of model typology, and utilized junior high school physical-science curricula to answer the question: Do the different value positions suggested by Macdonald to be inherent in each of his curriculum development models result in different content, or content organization?

To obtain information regarding the selection and organization of content in science curricula a sample of ninety teachers was randomly chosen from the English-speaking high schools in the Province of Quebec, Canada. These teachers examined physical-science curricula being used in the schools of Ontario and Quebec, then completed a questionnaire based on established criteria for the selection and organization of content for a science curriculum. A multivariate analysis of variance of the data for model indicated the presence of significant differences in the content associated with the three curriculum development models.

A discriminate analysis undertaken to determine how the models differed in terms of the criterion variables utilized in the questionnaire, resulted in two canonical variates that were significant. From the results obtained in this study it was concluded that:

1. Signigicant differences do exist in the content and its organization in curricula representative of Macdonald's three curriculum development models.
2. Content associated with contemporary, inquiry, utility, appropriateness, student's interests, student's needs, social and cultural, and social and cultural norms, was responsible for differentiation among the models.
3. Content representative of specific groups of selection criteria such as discipline-oriented, societal needs, and student needs was also responsible for differentiation in the content among the models.
4. From conclusion 3, there are different value positions in Macdonald's models which result in the selection and organization of different content depending on the model used.

Knowledge of curriculum development models which have been substantiated both theoretically and empirically is useful to educators involved in the development of a science curriculum. The educator is now able to make use of this information as a guideline during developmental procedures. Therefore, to the extent that the Circular-Consensus model is concerned with societal issues and the Dialogical has humanistic concerns, then a combination of these two models is suitable for an energy education development model. This model will involve administrators, teachers, laymen and discipline scholars concurring on the content and its organization in a curriculum from an assessment of students needs, interests, and abilities. The role of each of these persons operating within the rules of consensus is as follows:

(a) The administrator with expertise in curriculum development will instigate and administer the translation of scholarly materials into a defensible curriculum within the larger societal context. This person will also have knowledge of the teachers and be able to judge the various aspects of instructional strategies.
(b) The teacher will have an acceptable level of knowledge of the curriculum materials and of the learner for whom they are intended. A primary concern of the teacher will be matching curriculum materials with the students' needs, interests, and abilities.
(c) As representatives of the milieu, the laymen will have knowledge of societal issues, particularly those concerned with energy. A primary concern of the laymen will be that the curriculum materials are relevant to the student's understanding of energy as an important resource in contemporary society.
(d) The discipline scholar will have an intimate knowledge of the various aspects of energy. This person will ensure the authenticity of content and its organization in the energy curriculum.
(e) The student input will result from their response to a survey-type questionnaire for energy education.

The critical pathway to be used in the development of an energy education curriculum is as follows:

1. Discussion with school administrators regarding need for the energy education cirriculum, description of the development model to be used, and substantiation of procedure to be followed.
2. Establishment of an energy education curriculum development committee consisting of administrators, teachers, laymen, and discipline scholars.
3. Election of a chairman to this committee to ensure that the developers operate within the requirements of the model, particularly as they relate to the consensus of the group.
4. Preliminary consideration by the energy curriculum development committee for the determination of the students' needs and interests. The following is a list of possible topics for consideration:
    (a) Curriculum aims (or objectives).
    (b) Adolescent input.
    (c) Main features of survey.
    (d) Suitable energy questions.
    (e) Student selection procedure.
    (f) Explanation of project to students.
5. Students complete the energy education curriculum questionare.
6. Evaluation and discussion of the results obtained from the questionnaire.
7. Development of the energy education curriculum with the selection and organization of its content.
8. Implementation and Evaluation of energy education curriculum in the classroom.
9. From the results obtained in 8, possible revision and rewriting of curriculum materials prior to broad distribution.
10. Implementation of energy education curriculum with arrangements for ongoing evaluation and revision.

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3.2

NUCLEAR POWER IN THE CLASSROOM: A UNION OF SCIENCE AND SOCIAL STUDIES EDUCATION

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ABSTRACT
Science and technology, which once brought the United States and other industrialized countries of the world unprecendented energy resources and financial rewards, have begun to realize that politics and not the scientific method will determine the quality of life in the 21st century. Educators find it difficult to present nuclear power in a way that will allow students to make informed decisions and judgements on this issue. There is a need for unity in the science and social science fields, and presentation of material in an objective way incorporating both scientific and sociological aspects. Students need to make critical thinking and logic a standard in dealing with conflicting information. Major issues and arguments on nuclear power are presented, with possible classroom activities and resources cited.

A Need for Unity in a Changing World
Science and technology, which once brought the United States and other industrialized countries of the world unprecendented energy resources and financial rewards, have begun to realize that politics and not the scientific method will determine the quality of life in the 21st century. Nuclear power, as one source of energy for the past 25 years since the development of the first commercial reactor at Shippingport, Pennsylvania, has become a volatile issue in the United States and worldwide.

What responsibility do educators have in presenting energy issues such as nuclear power in the classroom? This paper will focus on nuclear power, the challenges it presents to educators at all levels in the field in preparing and presenting information in the classroom. This paper will cover two specific disciplines — science and social studies.

Nuclear power in the classroom has had a relatively short history in the annals of education and has been traditionally considered a part of the science curriculum for decades.

Historically, science educators, according to the results of a five year study by the National Science Foundation (NSF)[1], have reacted to the task of teaching science and technology from a "purist" point of view. This view as NSF reported caused students to "not learn the relationships between science and technology, hence as future citizens they were unaware of the roles that research and development play in an industrial nation and trade-offs and side effects that would affect them individually and collectively."[2] This was evident with the curriculum projects of the 1960s. The interest during that decade was to train youngsters to become sophisticated professional scientists who could advance technologies related to nuclear energy, space exploration, and oceanography that would enhance defense systems and national security.

In the social studies, however, nuclear power has not been given much space in its curriculum until recently. College and high school textbooks spent most of their space on nuclear power's relationship to weaponry, submarine and warship utilization, and other defense or military history including the devastation of Hiroshima and Nagasaki.

Historically, the social studies field found itself also responding to "governmental intervention and the pressure to make the public education system an instrument of social reform..."[3] Besides governmental pressures dictating curriculum, other forces were at work in our school curricula such as "currents and countercurrents including liberal and conservative ideologies, innovators, and traditionalists, accountability adherents, promoters of management by objectives, elitist versus populist philosophies, and advocates of technolgoical applications to education."[4] What then has this done to educators in terms of bringing controversial issues into the classroom?

Social studies educators reported in the NSF study that dealing with controversial issues in the classroom is a particularly significant problem. This problem has been based on their sensitivity to local feelings and values — a sense that communities expected their teachers would "pass on knowledge accumulated by others, rather than encouraging students to raise creative challenges or think critically."[5] This sensitivity to controversial issues has important ramifications to the role of "socialization" in our schools. A problem exists when a controversy surfaces in identifying whose norms or goals in respect to nuclear energy would be presented. If social studies has been identified as "perhaps the closest thing to 'value education' which exists in the regular curriculum of the public schools today,"[6] then the role and responsibility of the educator in presenting the nuclear power information in an objective manner is paramount.

The task then of presenting materials in an objective a manner as possible and making science more social oriented seems enormous. The key, however, to enacting objectivity through increased cognitive skill devleopment and becoming more socially oriented involving the affective domain of learning may be found in greater articulation of programs encouraging team teaching, and inservice training throughout elementary and secondary education.[7] Through an articulated program and a network of educators at all levels, curriculum infusion of energy education programs such as nuclear power, can make the "interconnection" possible.

Dealing with Conflicting Information

When educators are confronted with conflicting information on nuclear issues, the task of designing a class or series of classes that will increase students' understanding of the nuclear issues may appear to be impossible. When designing a class on controverisal issues the educator must be aware that accuracy of informational content needs to be considered from two perspectives. These perspectives are the correctness of the information and the intellectual honesty with which this information is presented.[8] The correctness of information is relatively easy to verify through experts from the relative disciplines. For example, the average background dose rate to an individual in the U.S. is about 100 millirems per year, and this information can be confirmed easily from many sources. However, the perspective of intellectual honesty of informational content is more subtle. Students must be made aware of the fact that some of the information presented is tentative, incomplete or based upon certain assumptions which are unproved. An example of this is the area of low level radiation. The student hears from one "expert" that low level radiation is not hazardous and hears from another "expert" that low level radiation is hazardous.

The intellectually honest answer to the questions of the health hazards of low level radiation is that the information available in this area is incomplete.[9] After being informed of this, students should then be allowed to evaluate the evidence and premises that lead to the conclusion that low level radiation is either hazardous or not. At this point students must apply critical thinking guidelines and the use of logic. For example, they can be asked, "Have arguments presented on either side of the nuclear issue contained information fallacies of relevance or ambiguity such as appeal to pity, hasty generalization, begging the question, or fallacy of accent?"[10]

Major Issues and Arguments

Before designing a class or series of classes on nuclear issues the classroom teacher should know the major issues surrounding the nuclear debate and some of the arguments on both sides of the issues so that information and activities can focus on these major points. Major issues in this case are defined as those issues which are most frequently debated in the United States but are relevant to the rest of the world as well.[11]

Issue #1: Nuclear Safety[12]

Basis for Concern: In the fission process large amounts of radioactive fission products are produced. Safety systems have been designed in order to prevent the accidental escape of these fission products into the environment. The public concern is whether or not these systems will work and protect the public from significant radiation exposure due to a serious commercial reactor accident.

Nuclear Advocates Say:[13] The excellent safety record of the nuclear power reactors to date demonstrates the safety of nuclear power. Even with the Three Mile Island accident (the most serious commercial nuclear reactor accident) no member of the public has ever been killed or injured because of a nuclear power plant accident. Improvements in safety designs over the years, with redundant backup systems and defense in depth concepts used in reactor safety systems, makes the probability of a major accident extremely small as demonstrated in WASH-1400.[14]

Nuclear Adversaries Say:[15] Even though there has not been a catastrophic nuclear plant accident, there have been many close calls and its only a matter of time before one of these problems result in a single nuclear accident that could result in thousands of deaths and injuries and contaminating a land area the size of Maryland. Small deficiencies in many areas of a nuclear plant combine to make the system unsafe. The numbers given by WASH-1400 for long term latent cancers and genetic defects for a particular accident were underestimted by a factor of 50.[16]

Issue #2: Health Impact

Basis for Concern: There are several different operations in the production of electricity from nuclear power that can result in radiation exposure to members of the public. This series of operations is referred to as the Uranium Fuel Cycle which includes mining and milling, fuel enrichment, fuel fabrication, power production, and radioactive waste disposal.

Nuclear Advocates Say: Radiation exposure to the public from nuclear power production is small when compared to exposure from natural background radiation. The health effects of nuclear power are less than the health effects of other energy alternatives such as coal.

Nuclear Adversaries Say: There is no safe level of radiation exposure. The health comparisons between nuclear and coal-fired generators focus on emissions from the stack of coal-fired generators ignoring hazardous radiation releases from other parts of the fuel cycle.

Issue #3: Nuclear Waste Management

Basis for Concern: Radioactive waste is the inevitable by-product of the generation of electricity by nuclear reactors. The intensity of the radioactivity present is very high. Immediately at reactor shutdown, a ton of spent fuel contains about 300 million curies of activity. Commercial waste is presently being stored as spent fuel assemblies, most of it in water-cooled facilities at the reactor sites where it was generated.

Nuclear Advocates Say: There are several adequate technical alternatives for storage of nuclear waste. If the spent fuel now being stored at the reactor sites were reprocessed, the more troublesome and longer lived radioactive species could be sepearated and reused for energy production, while the volume of the radioactive waste material to be stored would be reduced considerably. The most suitable repository for long term radioactive waste storage is in stable geologic formations which are known to have been unchanged for thousands or millions of years.

Nuclear Adversaries Say: There is no agreed upon safe way to isolate radioactive materials from the environment for thousands of years, a time span longer than human civilization. Nuclear storage facilities have had a hard time protecting wastes from the environment for even a decade. Radioactive wastes are a dangerous end to the fuel cycle, they are toxic. Once released into the environment they contaminate land and water virtually "forever."

Issue #4: Economics of Nuclear Power
Basis for Concern: The consumer is experiencing increases in the costs of nuclear power plant construction and electricity produced by nuclear power plants.

Nuclear Advocates Say: The cost of all forms of energy is growing and nuclear power is still the best bargain for producing electricity in most parts of the country when all factors are considered. Costs for nuclear power could be reduced if regulatory delays were reduced and if the Nuclear Regulatory Commission would streamline the licensing process for nuclear power plants.

Nuclear Adversaries Say: The cost of nuclear power is growing at a faster rate than other energy alternatives due to the rising cost of construction and operation, and low capacity factors. The nuclear industry would not have developed without enormous government subsidies.

Issue #5: Need for Nuclear Power
Basis for Concern: Conservation and other energy sources such as solar, geothermal, fusion, etc. may be able to replace nuclear power. Presently it is unclear whether or not these sources will be able to provide enough energy to satisfy energy needs in the face of diminishing fossil fuel resources.

Nuclear Advocates Say: Although conservation will help reduce energy growth there still will be a need to futher develop existing energy technologies such as nuclear power to provide energy needs while other energy technologies are being developed. Even with a large national committment to new energy technology research it will take 20-30 years for successful development and commercialization.

Nuclear Adversaries Say: There is no need for nuclear power. With immediate changes in America's energy wasteful lifestyles enough energy can be saved to make nuclear power unnecessary. If nuclear power development were curtailed or stopped entirely and the same funding applied to development of alternatives, such as solar energy, these energy alternatives could begin producing a significant part of the U.S. energy supply in a very short period of time.

Issue #6: Nuclear Proliferation
Basis for Concern: Nuclear reactors use fissionable uranium and produce plutonium. If properly processed, these materials can be used to produce nuclear weapons.

Nuclear Advocates Say: In today's world any country that wants to develop a nuclear weapon can do so with or without a commercial nuclear power industry. Thus far, nations who have developed nuclear weapons have done so by easier and faster means than processing fuel from a commercial reactor. Participation in international agreements and having adequate amounts of energy available for economic growth are the only ways of reducing the spread of nuclear weapons.

Nuclear Adversaries Say: The spread of commercial nuclear power technology can only lead to more countries developing nuclear weapons. Due to the proliferation of atomic reactors, about 30 countries have plutonium that could be used in bombs. Half of those countries have refused to sign the 1970 International Treaty on Non-Proliferation, thus exempting them from even the limited oversight of the IAEA.[17]

In addition to the major issues, some other issues that energy educators should be aware of which often become part of the nuclear debate include nuclear reactor siting, Price-Anderson Act,[18] terrorism, decommissioning of nuclear reactors, availability of uranium supplies, transportation of nuclear materials, breeder reactors, licensing and regulation of nuclear power plants and other nuclear facilities, morality of nuclear power, "hard" versus "soft" energy technologies and issues of importance to the local community.

Classroom Resources
In developing a strategy for presenting these nuclear issues in the classroom there are a variety of available resource that the classroom teacher can use. These resources vary from a one year course on nuclear science[19] to classes designed by other teachers, such as debates,[20] simulations,[21] creative dramatics,[22] and others.[23] This points to the important role the teacher must play in this entire process, including other people who impact on him or her at different stages of that role such as, teacher-educators, administration, support supervisory people, print and non-print producers/publishers of resource materials, inservice training personnel, teacher-peers, parents and the students. It is the teacher who will really make the difference in students, "who are for any one year most dependent on what that teacher believes, knows, and does — and doesn't believe, doesn't know, and doesn't do. For essentially all....learned in the school, the teacher is the enabler, the inspiration, and the constraint."[24]

[1] *What are the Needs the PreCollege Science, Math, and Social Science? Views from the Field,* National Science Foundation: Office of Program Integration, Washington, D.C., Vol. 8, SE 80-9, 1980.

[2] Reference 1, p. 68.

[3] Reference 1, p. 59.

[4] Reference 1, p. 66.

[5] Reference 1, p. 8.

[6] Reference 1, p. 128.

[7] Reference 1, pp. 68, 69, 130.

[8] Audrey Champagne and Leo E. Klopfer, in *Proceedings of the Sixth Annual Conference, Council for Educational Development and Research* (U.S. Dept. of Energy, Technical Information Office, 1977) p. 182-183.

[9] *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980* (National Academy Press, Washington, D.C., 1980), p. 1.

[10] A review of logical fallacies contained in an introductory text on logic will be extremely helpful in analyzing arguments on the nuclear issues, such as, I.M. Copi, *Introduction to Logic*, 3rd ed., (Macmillan, New York, 1969).

[11] *Nuclear Power Issues and Choices*, Report of the Nuclear Energy Policy Study Group (Ballinger, Cambridge, 1977) p. 1.

[12] For purposes of this discussion in this paper, a format of a statement of the issue followed by advocates' arguments and then adversaries' arguments has been arbitrarily established with no intent to make either set of arguments more favorable by its order in the paper.

[13] Nuclear advocate arguments can be found in a variety of books and articles, for example, F. Hoyle and G. Hoyle, *Commonsense in Nuclear Energy* (Freeman, San Francisco, 1980).

[14] "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," 9 Vols., U.S. NRC Report, WASH-1400, NUREG-75/014, October, 1975.

[15] Nuclear adversary arguments can be found in a variety of books and articles, for example, A. Gyorgy, *No Nukes: Everyone's Guide to Nuclear Power* (South End Press, Boston, 1979).

[16] Reference 15, p. 115.

[17] International Atomic Energy Agency.

[18] When nuclear power began to emerge in the U.S., Congress was concerned with providing insurance protection to the public and limiting the liability of the nuclear industry in the event of a major nuclear accident. To accomplish these purposes, the Price-Anderson Act was enacted in 1957 and renewed for the second time in 1976.

[19] See, for example, *Nuclear Science* (Pennsylvania Department of Education, 1977).

[20] See, for example, P.B. Hounshell and G.M. Madrazo, Jr., "Debates: Verbal Encounters in the Science Classroom," School Sci and Math 79 (8), 690-94 (1979).

[21] See, for example, P. Maxey, "Teaching About Nuclear Power: A Simulation" Soc Stud Rev 19 (2), 43-46 (1980).

[22] See, for example, I. Blair-Clough and B. Wheeler, "In the Shadow of Three Mile Island," Instructor 89 (2), 115-16, 118, 120 (1979).

[23] See for example, R. Parker, "Radiation and the Environment: A Relevant Course on a Topical Subject," J. Chem. Ed. 54 (7) 435 (1977).

[24] Reference 1, p. 63.

3.3

USING ISSUES RELATED TO THE ENERGY SOURCE NATURAL GAS AS ENRICHMENT FOR SECONDARY MATHEMATICS

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Abstract
The following discussion and set of problems are a part of an extensive study of natural gas — from the well to the consumer. Even this section is necessarily greatly reduced, but it should provide the reader with a sense of the general approach. Each aspect of the investigation is introduced with a brief description of the relevant issues and controversies, followed by a sequence of mathematical problems which should lead to some analytic conclusions.

Controversy Over the Danger of Liquefied Natural Gas (LNG)
There is a national debate over the potential dangers of LNG which parallels (although on a much smaller scale) the controversy over the hazards of atomic power generation. Industry proponents don't deny that LNG, if not handled properly, can cause a catastrophic accident, but they express confidence that they can deal with any problems that might lead to such an accident. People living near LNG tanks and shipping terminals have nevertheless expressed great fear of the potential dangers of these facilites and, in some communities, have engaged in resistance to their continued presence. Two accidents have heightened the apprehensions of an increasing number of people who live close to LNG storage and processing plants.

An accident in the liquefaction, storage and regasification plant of the East Ohio Gas Co. occurred on October 20, 1944. The fires and explosions of this disaster killed 130 persons and injured 222 more. The repercussions were so great that it was not until the mid 1960's that utilities again began using LNG. Another tragic accident occurred many years later, on February 10, 1973, when an LNG tank on Staten Island, New York, blew up, killing 40 workmen on a repair crew.

The Cleveland accident has been described in a comprehensive study of the many serious technical problems realted to the LNG industry: the Report to the Congress, *Liquefied Energy Gases Safety*, by the Comptroller General of the United States and the General Accounting Office (GAO) (July 1978). This three volume analysis concludes that LNG used as an energy souce is potentially so dangerous that its storage and transportation should be restricted, if possible, to remote, unpopulated areas. Asserting that a liquefied gas spill in a densely populated area would be a catastrophe, the GAO urged new federal policies that would ban the expansion of current liquefied gas facilities in urban areas.

Gas utility engineers, in response to the GAO report, claim that the Cleveland accident could not recur with current technology. They assert that LNG had an excellent worldwide safety record. Over one hundred LNG installations are operating throughout the world. More than eighty-five are operating safely in the United States. This safety record is maintained, they claim, by taking every precaution against any possible danger to the public. The GAO report has been attacked by Federal agencies (e.g. Department of Commerce and Department of Energy), as well as by the gas industry, as being misleading and a highly imaginative and alarmist compendium of potential disasters, rather than a dispassionate review of their actual probability or occurrence.

The GAO's response to the utility engineers is that although LNG technology has changed since 1944, it has not changed radically. The report asserts that the people who planned, built, and operated the Cleveland facility were trained, experienced, and reputable. They believed their plant was safe enough to be located in populated areas. In response to other Federal agency criticisms the GAO contends that they have approved LNG development without adequately assessing the hazards of LNG shipping and storage. Safety issues, the GAO claims, have often been overshadowed by economic considerations.

In an attempt to bring to market some of the large amounts of natural gas now flared and wasted in the Middle East and elsewhere, increasing use of tankers that transport gas in liquefield form is likely. These sophisticated tankers are cryogenic — or low temperature — containers. They are sturdy enough to resist impact, double-bottomed, and protected by several layers of linings around the hull. Four to six separate tanks insulated by special materials sit on top of the hull, forming an elaborate system of tanks, barriers, and linings which ideally are protected from possible leaks.

A great deal of research has been done to minimize the danger. Nevertheless, LNG tankers create much concern when they approach their ports. A New York Times reporter describes the great precaution taken at one port:
Every few weeks an unusual ritual takes place in Boston Harbor. As Coast Guard craft scuttle about like sheep dogs, herding other harbor traffic aside, a tank ship from Algeria moves slowly up the channel to a pier at Everett. Other vessels are kept clear of her course for two miles ahead and a mile astern, as if the ship were laden with explosives. (1)
If utility companies have their way, the cautious docking procedures found only in Boston in 1976 will be regularly emulated at many United States ports, including New York.

Problems

1. Once released from its frigid storage (- 260° F), LNG would quickly revert to a highly volatile gaseous form. LNG is so much colder than the surrounding air or earth or water that it immediately begins to vaporize, and, at an extraordinarily rapid rate, all the liquid will be gone. The resulting LNG cloud will hug the ground and roll out horizontally in all directions, far too cold and too dense to rise away into the atmosphere, as gas will do at normal temperatures. The gas cloud will continue to expand in size as it gradually warms up, mixes with air and blows downwind, lengthening out into a plume. It is one of the strange yet dangerous paradoxes of LNG that the initial freezing cold gas cloud is not flammable - it is too "rich" to burn. Only when the vapor has mixed with the air around it at proportions of 5 to 15 percent gas to air will it leap into flames if ingited. Any materials in its path are vulnerable.
Due to its slow evaporation rate, LNG does not suddenly ignite or explode. If the plume catches fire, it instead becomes a "lazy flame," slowly working its way back to the ignition source — e.g., the burning ship.
Industry spokesmen and some authorities, including experts at the Environmental Protection Agency, contend that such an occurrence is extremely remote. Other scientists, however, warn that LNG has the potential for causing massive holocausts, threatening in particular the densely populated areas surrounding ports.
a. One cubic meter of LNG makes approximately 420,000 cubic feet of a highly combustible mixture of gas and air. Show the calculations for this equivalence. (Three ratios are involved here: 1) the volume of LNG to the volume of natural gas: 1/600; 2) cubic meters to cubic feet: 1/35.314; 3) volume of gas to air in a flammable cloud: 5 to 15/100)
b. Forty cubic meters of LNG vaporized and mixed with air in flammable proportions could fill 110 miles of a 6-foot diameter sewer line, or 15 miles of a 16-foot diameter subway system. Check the calculations and discuss the statement.
c. For a 25,000 cubic meter spill, a staggering number of cubic feet of flammable gas mixture would be formed.
d. What about a really big LNG spill? Suppose, for example, that 100,000 cubic meters of liquefied gas (four fifths the amount carried on today's LNG supertankers) should spill into water? Discuss the volume of combustible mixture of gas and air and the potential disaster. (Such spills are highly unlikely but estimates like this underline the exceptional dangers which may be presented by the ever-larger LNG ships).
e. Find out if your community is in the danger zone of the "downing plume" which could emanate from the LNG tank or tanker. Invite speakers from industry and environmental organizations to discuss the major issues related to LNG.

2. LNG ships are built up to a thousand feet long, with cargo tanks over one hundred feet tall. They are fine-tuned, down to the tiniest detail, like a spaceship. Cargo tank sections are precision made, deviating from one another by the smallest of margins; all parts and instruments must be delicately designed and constructed so that they can expand and contract without jamming, splitting, or cracking, as the ship is unloaded and loaded.
LNG ship owners and operators are fully aware how vulnerable these ships can be in an accident, and a great deal of research has been done to minimize the problem. Nevertheless, danger still remains: a large spill could result if an LNG ships was struck by a sufficiently large vessel; or if there was sabotage; or if in the process of loading and unloading the liquefied gas an accident occurred as a result of human error. What would follow could be devastating.
a. The diameter of one of the aluminum spherical containers in an LNG tanker is 120 feet. How many cubic meters can be contained in each container? If a tanker carries 5 such containers, what is the total cubic meters of LNG contained in this tanker? This is equivalent to how many cubic feet of natural gas? This LNG tanker is carrying energy equivalent to 600 similar sized ships carrying natural gas!)
b. A typical ship with a capacity of 125,000 cubic meters of LNG is.approximately 930 feet long (approximately the length of three football fields), with a beam (width) of 140 feet, a draft (under water) of 36 feet, and a freeboard (above water) of 50 feet. Calculate the difference between the tanker's total capacity and capacity for LNG.
c. A ship carrying natural gas with the equivalent energy carried by the ship discussed in the previous problem, would have to have the following dimensions: 109 miles long, 15½ miles in the beam and a draft of 4 miles. Calculate the capacity of this fictitious natural gas tanker and compare it with the actual LNG tanker.
d. At least one supertanker will have a capacity of 165,000 cubic meters — enough liquid to cover a football field to a depth of over 120 feet (some 12 stories high). Show the calculations for this equivalence.

3. In the past decade LNG carriers have mushroomed in both number and size. As late as mid-1969, only three LNG ships were in world service. Now there are some 80 ships in service. Throughout the sixties and the early seventies, the averae size LNG ship could hold about 30,000 cubic meters of liquified gas; by the late seventies this figure almost trippled, with the standard size being built swelling to a cargo capacity of 125 - 130,000 cubic meters.

a. For the years 1964 to 1979, find the rate of growth in the number of LNG ships in world service.

b. Find the rate of growth in the total capacity of these ships.

c. Assuming a continuation of this rate of growth, what will be the number of LNG ships in service in 1985? What will be the potential total capacity of these ships?

d. In the light of the previous discussion and problems, discuss the implications of such growth.

Footnotes:

(1) *The New York Times*, October 7, 1976, p. 1

(2) Lee Niedringhaus Davis, *Frozen Fire*, (Friends of the Earth, San Francisco, 1979), p. 29

(3) *Frozen Fire*, p. 48

3.4

ENERGY AND SOCIETY: THE ROLE OF THE HUMANITIES IN ENERGY EDUCATION

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We have two means of bringing energy to use: by living things (plants, animals, our own bodies) and by tools (machines, energy-harnesses). For the use of these we have skills or techniques. All three together comprise our technology. Technology joins us to energy, to life. It is not, as some technologists would have us believe, a simple connection. Our technology is the practical aspect of our culture. By it we enact our religion, or lack of it.

—Wendell Berry

Background:

The New Alchemy Institute is a small non-profit organization dedicated to research and education. Our goal is to develop ecological approaches to food, energy, shelter, and community design. The strategies we research emphasize a minimal reliance on fossil fuels, operate on a scale accessible to families and small enterprises, and do not disrupt natural ecosytems.

For more than a decade now New Alchemists have been designing, building, and testing food, energy, and shelter systems that depend primarily on the Earth's renewable energy sources for their functioning. We are working in the areas of agriculture, aquaculture, wind systems, solar design, tree crops, and computer modelling. Whenever possible, we try to integrate our designs into economical, easily reproducible forms. We assume that through a sensible marriage of some modern technologies and an "ecological ethic," new approaches to meeting human needs can be devised that will permit all of us to live comfortably today without jeopardizing future generations.

New Alchemy's approach to design adopts a conceptual framework different from that used in traditional science. Traditional science and its methods, for the most part still support a Newtonian world view ruled by Classical Mechanics. New Alchemy's major work has been the synthesis of a theory of design that derives its justification from ecology.

Ecology seeks to understand and describe the "fluxes, movements of energy, and the physical dynamics of living systems."[1] Our research conducted within this framework has led us to conclude that:

> Means of biological productivity and ecoystem structure and function can provide a model applicable to technological development. Similar patterns are found within organelles, cells, organs, organisms, ecosystems, and the biosphere. These systems function by efficiently cycling renewable resources including nutrients and energy available within the environment. Human societies can also be structured to function in this manner.[2]

Of course today most human societies are not structured this way. Instead they are based on highly centralized and inflexible systems of life support that depend upon the continuous input and consumption of large amounts of the Earth's nonrenewable energy "capital" in order to function.

A direct consequence of this short-sighted planning is our perceived energy "crisis." When human institutions are faced with events its experts failed to anticipate, we respond by calling them crises. There is an energy crisis because the original architects of our modern industrial society assumed that a limitless supply of fossil fuels was at humanity's disposal.

Consider our country's food system, for example. Today American agriculture is structured around agribusiness — a highly centralized, vertically integrated food industry that produces, distributes, and markets a truly prodigious amount of food each year. However, the ultimate price that society must pay for this prolific rate of food production raises some very serious questions about the logic of some of agribusiness' underlying assumption.

Nearly seventeen percent of all the energy consumed by the nation's economy is used by agriculture.[3] In addition, American agriculture requires an input of eight calories of energy for every calorie of food energy it produces. Furthermore, a great deal of the energy pumped into agriculture is in the form of chemical fertilizers, pesticides, and herbicides. The repeated introduction of these chemicals into the environment pose a threat to the health of our ecosystems and to all the organisms supported by them.

Ecology instructs us to pay attention to structure. Adopting an ecological perspective helps us discover natural cycles and patterns of energy flow. When energy issues are addressed from within this conceptual framework, we are guided by a new set of values toward strategies that impound, conserve, and recycle renewable forms of energy and to the creation of energy systems and societies that are sustainable — that endure because their designs are based on adaptive biological principles of co-evolution and self organization. This approach to problem solving suggests that it is possible to design environments that are sensitive to the needs of both the biosphere and society.

New Alchemy's bioshelters embody these ecological design principles. Bioshelters are solar heated buildings that link a variety of biological components in new, food producing ecosystems. Inside our Cape Cod bioshelter called the "Ark" we use fourteen fiberglass cylinders called solar algae ponds to collect, store, and release most of the heat required by the 1,950 square-foot greenhouse/fish farm. Each solar algae pond measures five feet in height and diameter and is filled with about 650 gallons of water. The heat released over the Cape's 150-day heating season by each pond is equivalent to the heat released by burning 30 gallons of home heating oil. Moreover, each pond also functions as an aquatic ecosystem. Their design for optimizing the entry of solar energy also maximizes their potential for biological production.[4] Fish production inside each pond ranges from between 35 to 50 pounds per pond per year. The fish (*Tilapia*) are raised as a source of protein for human consumption.

Our bioshelters link agriculture, aquaculture, and passive solar design in a way that optimizes their relationships. Our attempt is to replicate natural ecosystems as best we can. The fish systems provide irrigation water and nutrients to the crops. The weeds, cuttings and other agricultural by-products are in turn fed to the fish.
As users we can preserve energy in cycles of use, passing it again and again through the same series of forms or we can waste it by using it once in a way that makes it irrecoverable.[5]

All this suggests that the decisions that society must make with regard to energy use are not all of a purely technical nature. Our energy policies will also reflect our values. We should be clear as to just what those values are. The manner in which we choose to approach energy issues will say a lot about how we choose to relate to one another and to our environment. Therefore, energy education programs must stress more than just the scientific side of the energy question.
We must integrate the humanities into our energy curricula so that individuals will be exposed to the ideas and philosophies that will help prepare them to deal with the difficult social and ethical questions related to energy use.
....before we choose our tools and techniques we must choose our dreams and values, for some technologies serve them, while others make them unobtainable.[6]

If our goal is to discover educational strategies and programs that will enable members of society to make intelligent decisions about personal and global energy matters, we must begin by acknowledging the need for a more holistic understanding of the dynamic interplay between the ethosphere and biosphere.

There is, however, a genuine crisis within our institutions of learning that threatens to make this goal more difficult to achieve than one might expect. Recent attacks (by parents, teachers, and civic leaders) against the teaching of "secular humanism" in our public schools is at the crux of this matter.
Humanism is a philosophy of teaching that encourages free thought and scientific inquiry without deference to a supreme being or any absolute standard of ethics.
Humanism acknowleges no sacred cows. It calls everything to question — God, law, country, tradition — nothing is exempt. When undertaken in a responsible way, this kind of teaching can be extremely creative and constructive. However, a growing number of individuals throughout the country believe that the teaching of secular humanism is the source of most of society's current woes. They see humanism breeding irreverence, disloyalty, and sacrilege. These opponents of humanism are demanding that its books and curricula be purged from their school systems. They are specifically aksing for "history texts that emphasize the positive side of America's past, economics courses that stress the strengths of capitalism and literature that avoids divorce, suicide, drug addiction, and other harsh realities of life." (N.Y. Times/May 17, 1981).

We cannot ignore the connections between the "harsh realities of life" (which also includes war, racism, sexism, and other forms of oppression) and the technologies that play a major role in determining the structure of society. Nor can we as educators eliminate these painful realities from our curricula until they are first eliminated from society. If we become censors it will be at the expense of our integrity.

Science is not value free. Since there is no empirical test for values, science teachers must look to the humanities for help in grappling with all of the implications (social, political, philosophical, ecological) of our technological responses to society's energy problems.
The New Alchemists have accepted these educational challenges and are addressing them in a number of ways. We offer guided tours of our twelve-acre research facility, courses, workshops, day-long public education programs and a variety of publications. Our two most ambitious educational projects to date are our high schools Design Science Curriculum and our involvement in The Cape and Islands Self Reliance Corporation.

The Curriculum
We are in the process of developing a high school curriculum that describes the philosphy and principles of the Design Science approach to problem solving. Design Science recognizes that it is possible to meet the needs of human society and at the same time remain sensitivie to the needs of the biosphere that supports us. The goal of this project is to introduce students to the values and techniques inherent in the pursuit of ecologically derived forms of food, energy, and housing, and to develop confidence in their own problem solving skills.

New Alchemy's Design Science Curriculum will be both interdisciplinary (bringing together a number of sciences to stress the importance of discovering the relationships between energy use, food production, architecture, ecology and social organization), and multidisciplinary (drawing on such disciplines as history, political science, anthropology and literature to create cultural and social contexts for teachers and students) in its approach. In addition to a lesson plan and course outline, it will suggest ideas for activities and projects that will help teachers and students discover how their individual and collective actions can effectively and humanely address global concerns such as energy and pollution. The format for each section of the curriculum will be designed to encourage students to "think globally" and "act locally."

The curriculum will consist of four interrelated units: Systems of Knowledge; The Evolution of World Views; Principles of Design Science; and Appropriate Technology. The first two units rely heavily on the humanities to create the conceptual framework for the final two units. A more detailed description of each section follows.

1. *Systems of Knowledge.* What do we really know about the Universe, and how do we know it? This unit will examine the different systems human cultures have devised for looking at and describing the world around them. The relationship between science, philosophy and religion will be discussed in some detail. Important epistemological concepts such as Gregory Bateson's "ecology of ideas" will be introduced. The objective of this unit is to demonstrate that although science provides the basis for Western civilization's world view, other "ways of knowing" exist and should be respected.

2. *The Evolution of World Views.* How do your students perceive the world? What influences these perceptions? What do your students feel are the most important issues facing humanity today? Are these problems solvable or not? This unit will help students understand and express how *they* think the world works. It will also point out how humanity's world views have evolved over the centuries, and how changing world views affect the way that we see and approach problems.

3. *Principles of Design Science.* This unit will begin with a brief history of science and the development of the scientific method. It will contrast the differences between the ecological and mechanistic world views. It will conclude with a thorough discussion of Design Science's holistic problem solving techniques.

4. *Appropriate Technology.* The principles of design science are made manifest in their applications as appropriate technologies. Appropriate technology is a small-scale local approach to a global problem. In this unit students will explore the strategies developed at New Alchemy and other appropriate technology organizations around the world that attempt to address the global problems food, energy, and shelter. Particular attention will be paid to the relationships between society's various support systems.

The curriculum package will be designed so that teachers will be able to integrate it into their existing lesson plans (by pulling out individual units or sub-units), or use it as the basis for a semester long course. The entire package will consist of lesson plans, teachers' guide (including evaluative tools/techniques), student hand-outs, and an annotated bibliography. Throughout the curriculum, suggestions will be made on how some sections might be team-taught.

The Cape & Islands Self Reliance Corporation

During the winter of 1979, the New Alchemists were contacted by the Community Action Committee (C.A.C.) of Cape Cod and the Islands and asked to take part in the planning and implementation of a regional food and energy assistance agency for Cape Cod — The Cape & Islands Self Reliance Corporation.

C.A.C. is the Cape's local anti-poverty agency. Since its formation in 1965, it has consistently committed itself to organizing efforts centered around the needs and concerns of the Cape's low income residents. During the past ten years C.A.C. has been instrumental in helping to bring about major changes in the areas of housing and health care for the Cape's poor. Through its work, the staff of C.A.C. was made well aware of the heavy burden rising food and fuel costs were placing on the Cape's already beleagured elderly, unemployed and underemployed.

Cape Cod and the Islands of Martha's Vineyard and Nantucket rank at the top of Massachusetts' charts in both energy and food costs. In many cases, families with annual incomes of less than $7,000 must spend as much as a quarter of those funds just to heat their homes in winter. Thousands of Cape residents are forced to apply for fuel assistance to meet their energy needs.

While many government programs such as fuel assistance and food stamps help many families meet their fuel and food expenses, they do virtually nothing to lessen the receipent's dependence of fossil fuels, agribusiness or future assistance. On the other hand, the Self Reliance Corporation is designed to offer individuals and families opportunities to achieve some measure of self sufficiency in food and energy.

The goal of the Cape & Islands Self Reliance Corporation (hereafter referred to as Self Reliance) is to reduce the net export of funds from the region for food and energy by bringing economical, alternative food and fuel resources into every member's home. Self Reliance offers skills, knowledge, and hardware necessary to premanently increase members' control over their food and energy supplies, while guaranteeing a measure of independence from escalating costs.

Six agencies in all have pooled their expertise and resources to help make this happen. Joining New Alchemy and C.A.C. in this effort are the Cape's Housing Assistance Corporation (H.A.C.); the Energy Resource Group (E.R.G.) of Martha's Vineyard; and the Wampanoag Tribal Councils of Mashpee and Gayhead.

Membership in Self Reliance is open to all Cape residents, although our focus is on the needs of low-income consumers. Self Reliance provides a vehicle for members to share skills and labor. In addition, when fully staffed, Self Reliance will offer the following services to its members:

a) A comprehensive home food and energy audit that will show:
- where energy can be saved
- how energy can be saved and what materials are needed
- how and where food can be grown
- how much each improvement will cost

The audits provide the basis for members to begin their own home food and energy improvements.

b) Financial counseling on federal, state and local loan/grant programs with money available for weatherization and other home energy improvements. Staff will also provide assistance in preparing loan or grant applications.

c) Self Reliance offers training, instruction and technical information on topics such as home energy conservation, small-scale ecological gardening, and construction and installation of low-cost solar devices.

d) We envision a centrally located warehouse or store through which members will be able to purchase weatherization and building materials, gardening tools and supplies, and energy-saving products at reduced rates.

Members of the Cape and Island Self Reliance Corporation feel that the solutions to the Cape and Island's food and energy problems will be found when we discover how to make the best use of our own human and renewable resources.

> Humanity is about to discover
> That whatever it needs to do
> And knows how to do
> It can always afford to do
> And that that in fact is only
> And all it can afford to do
> —R. Buckminster Fuller

Footnotes

1. John Todd and Nancy Jack Todd, TOMORROW IS OUR PERMANENT ADDRESS (Harper Colophon, New York, 1980) p. 47

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3.5

THE NEED OF A NEW DESIGN OF STRUCTURE OF EDUCATIONAL KNOWLEDGE FOR COPING WITH THE STUDY OF ENERGY AND ENVIRONMENT.

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Consequently the general task of education is the compliance of culture with historical exigences. Culture means essentially the process of adaptation of thought to reality.
Since the improvement of culture is easy measured by the ability to utilize energy for human needs of production, it is possible to find a direct relationship among the amount of 'energy' per capita (E), technological means (T), and production of goods and services (P), and culture (C). In schematic formula:

$$E \times T \propto P + C$$

(see: L.A. Withe-Energy and the evolution of culture-in: American Anthropologist 45 (3), 335-356, (1943).)
This schematic representation of interrelationships between energy sources and technology, in relation to the historical period of the industrial society, gives particular forms to the structure of production and culture.
The reach of the maximum of productivity in correspondence with the possibility of increasing the energy input, generate particular types of social division of labour.

The father of modern economy, Adam Smith, regarded improved division of social labour as the main cause of increased productivity. Referring to a description of a needle's factory A. Smith describes the growing agility of the hands when the manual labour is dissociated from the mental one and subdivided into different types of simple manual actions. (see: Adam Smith - The wealth of nations-Harmandsworth-Perguin (1970) p. 110).

In fact, with respect to the method of production of the handicraft, the historical tendence of the development of the factory system is towards a progressive "deskilling" of manual work, which becomes then, easily replaciable.
To comply with this system of production and for ruling society and controlling production, became a need the grow of schooling system that has two main functions: on the one side, to obtain an ideological acculturation of the people (general education), and, on the other side, training few people to take decision about production.

Changes in technology of production (for instance, automation, electronic processing etc...) which produce different work exigences, increase the need of differentiation of intellectual competencies and therefore schooling must translate such requirements in terms of education and training.
Since a functional schooling sistem reproduces, in term of instruction, the culture of the epoch, hence the cultural structure of this historical period in subdivided in specialisms that are necessary to follow the dynamical evolution of the factory system of production.

Production, culture and technology, as a whole, grow through an unilinear type of developmental process that is associated with the necessity of a constant increase of energy input, mostly from not-renewable resources.
The present energy crisis puts in clear evidence that this unilinear development has a physical limit of growth.
When a specific mode of production reaches the limit of its development, a period of transition through a new mode of production begins. Since human thought is the guideline of human praxis, we note that in this period of transition between modes of production a cultural revolution occurs.
As a matter of fact, before the crisis, culture, in general, follows the need of the evolution process; after, during the crisis, culture must be oriented to solve new problems of the transition society.
Therefore the culture is no more only related to the old system of production but, instead, to the creative forecast of future developmental processes. (see: -No limits to learning- by: The club of Rome-Pergamon Press Ldt. Oxford- (1979).)

Appropriate education is the precondition for being able to work and live in the society. In consequence inthe present transition period towards different modes of production, the conservative educational system is no longer adequate and a revolutionary theory of

education, oriented to understand and solve problems characteristic of a post-industrial society is mandatory.
To day we are urged to solve simultaneously serious problems, as the utilization of renewable resources of energy and the production of new appropriate technologies, various social and economic problems, e.g. unemployment, inflaction, and other environmental effects.
It is easy to understand that all those problems, which deserve an alternative mode of production for solution, are global-problems.
The traditional science organized on the basis of various fragmented disciplines, generally does not give a coherent vision on topics of contemporary relevance and utility, therefore for obtaining an educational finalization of knowledge, for understanding and solving global problems, it is necessary to propose an alternative structure of educational knowledge.

From the last observation it is emerging that one of the basic difficulties that arises against the innovation of a new education, aimed to give the cognitive precondition for understanding global problems, is due to the historical structure and organization of knowledge. As a matter of fact this is subdivided into academic disciplines and organized in a solid framework of social institutions of traditional culture (schooling and research system), which, due to their deep specialization, are not able to face global problems.

Another very big question is correlated with the successive need of solving (and not only understanding) contemporary problems, like energy, raw materials, alimentation, pollution and so on.
For solving those problems at first it is necessary to grow up a new mentality that correspond to reverse the historical tendencey of "deskilling" manual work.
In this case is needed a very deep change of the social function of schooling that up to now acted to reproduce the social division of labour into study and work.
Hence an integration of disciplines finalzed to understand global problems, and a process of growing a 'permanent' educational system for workers are the fundamental needs of schooling transformation.

In this general perspective a change in the curriculum so to obtain an appropriated understanding of energy problems (with the aim to help in solving the global problem connected with the energy crisis) is presently very hard.
In spite of this difficulties, reaching a new link between the structure of educational knowledge and contemporary developmental environment, is a theme of vital importance.

SESSION 4: GENERAL INTERDISCIPLINARY COURSES

4.1

ENERGY PERSPECTIVES IN COLLEGE EDUCATION

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Abstract
The relatively new field of energy education presents balanced perspectives of major energy issues and in so doing, prepares students for making informed decisions on personal and societal energy matters. A one quarter course at the University of North Florida emphasizes the principles of thermodynamics and net energy, the economic and energy efficiencies of food production technologies, present energy problems, conservation philosophies and future energy scenarios. Classroom discussions include controversial subjects such as nuclear safety, environmental effects of energy production, public energy policy and lifestyle versus standard of living adjustments. Students complete research projects oriented toward a local or regional energy matter of current or imminent significance.

As part of an innovative science education program for liberal arts students, the Department of Natural Science at the University of North Florida offers a one quarter course entitled, "Energy: Past, Present and Future." The course is designed to satisfy a science requirement for nonscience majors working toward a Bachelor of Arts degree. The objectives of the course are:
- to familiarize students with essential facts and scientific principles which are relevant to the production, conversion and utilization of energy,
- to convey balanced perspectives of major energy issues,
- to provide a background of information on which students can base decisions on personal and societal energy matters,
- and to stimulate students to read energy related resource material.

This course begins with a presentation of the evolution of the universe from its fiery beginning as a single "cosmic egg" with an energy density over 40 billion times that of water[1] to its present mass and gravitational energy dominated system of galaxies, interstellar material and space. Discussions of mass and energy interconversion, conservation of angular momentum, mass recycling and unidirectional energy flows provide a context for the examination of mathematical relationships between energy and other physical quantities such as light frequency, mass, velocity, etc. The discussions also put the Arab oil embargo, escalating gasoline prices and high electric bills into the background (temporarily) in comparison with the power and grandeur of worlds developing and dying.

The laws of thermodynamics are introduced without recourse to mathematical formalism in order that their meaning can be explored in the context of common experience. Later, at an appropriate time, fundamental equations are presented to show the relations between energy, heat, work, enthalpy, entropy and free energy. Some convenient introductory statements of the first and second thermodynamic laws are:[2]

First Law
- The quantity of mass/energy in the universe is constant.
- Energy is neither created nor destroyed in a nonnuclear process.
- Perpetual motion machines of the first kind are impossible.

Second Law
- Energy generally degrades from a "high" form to a "low" form spontaneously but not the reverse. (For a hierarchy of energy forms, see reference 3.)
- Perpetual motion machines of the second kind are impossible.
- The entropy of the *universe* increases in a spontaneous process.

A description of perpetual motion machines of the second kind requires the definition of energy conversion efficiency and offers an opportunity to compare the efficiencies of various natural and man-made conversion systems.

Armed with these fundamental concepts of energy conservation and conversion, the course turns to the subject of human energy consumption. Using the energy language developed by H.T. Odum,[4] energy flows of the major energy producing technologies are compared *including* their developmental and feedback energy costs. This perspective emphasizes the *net* energy return from each technology or system.

An historical perspective of food production in the modern world is developed by tracing man's agricultural history from hunting-gathering days to the present[5–7] and by comparing natural ecosystems with modern agriculture (Table 1). Trends in relations between energy inputs to U.S. agriculture and output parameters suggest no more major production jumps for the U.S., and hard times for energy poor third world countries.[6–8] Analysis of energy inputs to the American food system shows that primary food production energy costs are a small part of U.S. energy expenditure (3-4%),[9–10] but that food processing, packaging, distributing, marketing and preparing energy costs are four to five times larger.[9] The proposal that Americans eat lower on the food chain is presented in the context of saving energy, saving money, and perhaps improving diet quality.[11]

A fundamental service which energy educators can provide is to construct for their students a realistic perspective of their energy future. Although the popular media now recognize the reality of present U.S. energy problems, they usually fail to provide a balanced view of what the energy situation will be like for the next 30 years. As a result, students often ask questions of the type, "If we can go to the moon, why can't we have a solar economy by the year 2000?" There are a variety of publications which give good summaries of 20th century and early 21st century energy supply and demand patterns[12–16] and of the breadth of options available to the United States for the next 30 years.[14–20] Some of the important conclusions to draw from such material are:

(1) Although the long term energy supply situation looks quite favorable, in the short term there are likely to be economic and social shocks stimulated by energy problems.

(2) While the development of coal and nuclear power will dominate the U.S. national energy picture in the near future, other low

technology energy sources can make highly significant impacts at personal levels.

(3) Estimates of finite resources lifetimes should be made using roughly bell-shaped resource production curves [illegible] rather than straight lines or exponential curves.[23]

(4) The length of time required for a new technology to make a significant economic impact (much less play a dominant role) is 30-40 years.[20]

(5) We live in a transitory time, the Epoch of Fossil Fuels, which even by human time scales is quite short.

(6) The fact that the earth now offers a large amount of energy in a readily useable form (fossil fuels) can be viewed as an opportunity for human industrial and technical evolution to the age of sustainable energy resources (breeder reactors, solar power, geothermal energy and nuclear fusion).

(7) A good argument for the maintenance of highly industrialized and moderately energy intensive societies is that only they can develop the technical expertise required to provide mankind with an energy rich future.

Because our energy course is designed to satisfy a science requirement for liberal arts students, a substantial portion of the term dwells on the technologies of producing and consuming energy.[22, 24-26] Included in the discussions are topics such as the chemistry of fossil fuel combustion, the physical and chemical processes of crude oil refinement, the chemical processes of coal gasification, radioactivity, nuclear fission and nuclear power plant design. The latter is examined closely in a discussion of the Three Mile Island accident.[27]

As appropriate, the environmental effects of each technology are discussed [16,24,28,29] including thermal pollution, air pollution from fossil-fuel utilization, nuclear waste generation and disposal alternatives, and local and global climate alterations.

Perhaps the most popular section of our course deals with the technologies and the economics of renewable energy sources. Even though most students are convinced by the foregoing discussions that these inherently appealing sources of energy will have a relatively small national impact in their lifetimes (the average student age at UNF is 30 years), they are nevertheless enthusiastic about personal scale applications and large scale research and development for the benefit of future generations.

The discussion begins with an examination of the total energy flux to the earth [30] of which, only solar and tidal energies are renewable. Geothermal or terrestrial energy is included in the discussion since its expected lifetime is so long. The treatment of solar energy is divided into two sections:

A. Direct radiation capture by human technology: space heating and cooling, water heating, thermal conversion to electricity and photovoltaics.

B. Capture of solar radiation by natural systems followed by human conversion: wind power, hydroelectricity, ocean thermal gradients and biomass.

The magnitude and characteristics of the solar resource and the design features of passive and active systems [31, 32] are presented in consideration of their suitability to Florida's lattitude and climate. The economics of solar applications are an important part of the discussions and are explored in depth by later presentations (below).

In the post oil embargo years, American quickly realized the immense potential for energy conservation through eliminating wasteful habits, replacing inefficient machines and processes with more efficient ones, incorporating energy saving technologies and management systems and shifting from energy-intensive activities to less energy-consuming ones. Phrases such as, "Six per cent of the world's population uses thirty per cent of the world's energy" and, "Americans waste more energy than they use" must be tempered by the perspective that until recently, energy was inexpensive and getting more so. Now that this trend has reversed, a discussion of the price elasticity of energy demand[33] helps students learn how flexible the U.S. economy is in the short and long terms. Short term estimates of the total potential for conservation are around 10%, while long term estimates are more in the neighborhood of 40-50%.[35, 36] Some useful conclusions to draw from energy conservation discussions are:

* Many energy conservation techniques use simple, low technological methods[37]
* Three inputs to the economy which can be substituted for one another are energy, capital, and labor. Their relative costs help determine their optimal distribution.
* There are no firm correlations between national energy consumption and gross national product.[39]
* A reduction in personal energy consumption does not necessarily require a reduction in living standards.[40]

Toward the end of the term, students present summaries of individual research projects to the rest of the class. The topics focus on energy matters of current or imminent significance. Examples of project titles selected by students are:

The Economics of Gasohol
Floating Nuclear Power Plants
The Energy Cost of Pollution
Solar Home Economics
Energy Efficient Building Construction Techniques
The Third World and the Energy Crunch
The Geopolitics of Energy
Personal Energy Independence

Our course has been favorably received by students and usually fills early in the registration period. A typical students reaction toward the end of the term is "Why didn't somebody tell me this before?" One student remarked that she thought such a course should be required of all B.A. graduates. While her opinion may be extreme, other Florida educators also reported enthusiastic student responses at recent energy education conferences in Orlando and Tampa.

Table I

Attributes of Natural Ecosystems and Modern Agriculture

Natural Ecosystems	Modern Agriculture
Large diversity of organisms	Low diversity of organisms
Large genetic diversity for any single species	Low genetic diversity for any single species
Stable communities	Unstable communities
Active competition for nutrients and energy	Suppressed competition for nutrients and energy
Natural energy inputs only	Energy inputs supplemented by human activity
Slow growth rates	Fast growth rates
Low yield	High yield

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4.2

DEVELOPING AND TEACHING A UNIVERSITY COURSE ON ENERGY MANAGEMENT

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Trigger Factors and Course Justification

The embargo by the Organization of Petroleum Exporting Countries on crude oil shipments to the United States in the fall of 1973, and the unilateral price hike which exceeded 100% on January 1, 1974, were historic events. The immediate results were gas shortages, higher prices, and long waiting lines, as well as shock, anger, resentment, and impulsive but unrealistic vows to become energy independent. The delayed results were the gradual realization that (1) the United States had become very dependent on imported crude oil and highly vulnerable, (2) the practices and policies of consumers, firms, and governmental units resulted in wasteful consumption of energy, and (3) the days of cheap energy were gone forever.

In September, 1973, Dr. John H. Gibbons left our campus to work on energy plans in Washington, D.C. and subsequently served as Director of the Office of Energy Conservation in the Federal Energy Administration. He returned to The University of Tennessee a year later to resume direction of environmental and energy research.

In 1974, The Energy Research and Development Administration was created and given broad research and development responsibilities for all types of energy production and utilization. Dr. Melvin H. Chiojiogi was the Assistant Director for System Analysis in ERDA's Division of Buildings and Community Systems in the mid-1970's, and he recognized the importance of energy conservation in all types of operating facilities. He also felt that future managers must be better educated to manage energy efficiently and believed that a university-level course on energy with a management orientation rather than an engineering design focus was sorely needed.

After the interest of ERDA in university-level energy conservation education was recognized, Dr. Gibbons contacted several interested faculty members about participation and submitted a proposal to ERDA. In February, 1976, The University of Tennessee Environment Center received a contract from ERDA to develop, teach, evaluate and disseminate a university course entitled Energy Management — Theory and Practice. The objective of ERDA was to obtain a pilot course which could be made available to educational institutions everywhere. The basic justification was that the United States must manage energy resources much more carefully in the future than in the past, and in order to do so, persons in management positions must have better training for making energy-related decisions.

Thus, the three factors which triggered our efforts were (1) the OPEC-imposed embargo and price hikes on crude oil (2) the interest and experience of Dr. Gibbons related to energy conservation, and (3) the interest and vision of Dr. Chiojiogi and his associates in ERDA.

Course Design By Interdisciplinary Team
In order to develop and teach a comprehensive course on energy management, faculty members were needed from many academic disciplines. The team which developed the course discussed herein included J.H. Gibbons (Physics), F.W. Symonds (Electrical Engineering), W.T. Snyder (Engineering Science and Mechanics), R.A. Bohm (Finance), J.R. Moore (Economics), and H.W. Henry (Industrial Management). This group was divided equally between physical and social science disciplines. We met many times to select topics for inclusion in the course and often disagreed, but a spirit of cooperation prevailed.

The first consideration in designing the course was to provide an overview of the past, present, and projected future supply and utilization of various types of energy in the United States and in the world. Next, basic concepts of physics and engineering, economics, management, and finance were included so that students could understand specific energy issues and ways to deal with them.

The third focal point and the dominant theme of the course was on energy management in operating facilities such as industrial plants, commercial buildings, and homes. Heavy emphasis was given to methods for conducting an energy audit and for identifying, evaluating, and selecting for implementation various energy conservation opportunities. Investment analysis methods were included for analyzing capital spending proposals. Also, the steps in introducing a formal energy management program were included.

In order to provide personal experience in managing energy, the team decided early in the planning stages to require each student to participate with two or three other students in an energy audit of a factory or building in the community. This type of hands-on experience was considered more valuable than anything which might be done in the classroom.

Another area of emphasis was the types of responses made by business corporations to cope with the higher prices and energy shortages after the embargo in 1973. Also, the policies of the U.S. Government before and after the embargo were included, and so were new legislative acts and programs since the embargo.

Finally, energy supply and utilization technologies and environmental impacts were included. The primary emphasis was on current and developing energy sources.

Content of Course and Teaching Approaches
To start the course, a U.S. Department of Commerce film entitled "A Time To Choose" is shown. It depicts the energy supply and demand imbalance which is likely to occur in the United Statesin the next two decades. This movie causes the students to recognize the seriousness, the uncertainty and the complexity of our energy situation. Viewgraphs are then projected to show various statistical data about energy supply and utilization.

In the next session, energy and power are defined and units of measure and conversion factors are reviewed. Various forms of energy are discussed, as well as methods of converting from one form to another. Examples of energy conversion systems, the laws of thermodynamics, and methods for measuring conversion efficiency are presented.

Economic concepts of supply, demand, markets, prices, elasticity, and equilibrium are reviewed in the third session. Viewgraphs are used to illustrate simple economic systems and the impacts of energy-related decisions by consumers, producers and government policy makers.

Basic concepts of management and organization theory such as objectives, resource flows, planning, execution, control, decision-making systems and processes, authority hierarchies and organization structures are reviewed in the fourth session. A distinction is drawn between operational and strategic plans to conserve energy, and investment analysis methods are reviewed.

In sessions 5, 6 and 7, the focus shifts to energy management in operating facilities. Detailed procedures for conducting an energy audit, included the billing audit and field audit phases, are reviewed. This involves the establishment of historical monthly energy consumption and cost patterns for each type of energy. Then current consumption rates are determined for each type of energy in each application from nameplate data or equipment ratings. Operating schedules are estimated for each energy-consuming apparatus and monthly usage levels and costs are calculated. Total energy consumption is subdivided by applications such as process equipment, space conditioning, and lighting, to determine areas of greatest potential savings.

Every idea for energy conservation is expanded and evaluated to determine its potential for energy savings as well as its implementation costs. The ideas which yield benefits greater than costs and which meet capital investment acceptance criteria are recommended for implementation. Student teams of three or four persons each are assigned to conduct a complete energy audit in a local factory, supermarket, school, church, or home. A formal report is prepared and an oral summary of the project is presented in class near the end of the term.

In order to recognize practical impacts of the changing energy situation and the subsequent responses to various groups, the types of decisons and actions taken by business corporations and governmental units in the 1970s are reviewed in the next two sessions. Newspaper clippings, annual reports, and other company publications are used to identify specific responses of corporations to more expensive, less reliable energy supplies. A wide range of actions has been taken by business firms, including extensive energy conservation programs, product design and product mix changes, plant relocations, diversification moves, vertical integration to obtain energy sources and others.

Government responses have included reorganizations, new policies, procedures, and regulations, as well as new programs passed by the U.S. Congress which pertained to energy research, utilization, taxation, pricing, and conservation. These changes are reviewed, using government publications and newspaper accounts as sources. Also, new state and local government initiatives are discussed, as well as the responses of consumers and other institutions to the energy situation.

Finally, the status of current energy sources and developing energy supply technologies is discussed in terms of projected production rates, demand rates, and price outlook. Factors which will affect the production and utilization rates of various types of energy in future years are also discussed. These include social, political, economic, technological, and physical considerations. The environment impacts of energy production and utilization are given special emphasis. Also, new technologies and products are cited which will affect energy demand, such as computer-controlled process and building operations equipment, microwave ovens, new home and building materials and designs, new vehicles, other home appliances, and industrial equipment.

Among the energy supply technologies, coal conversion methods, nuclear fusion, nuclear fission, and solar systems are discussed in more detail than wind, geothermal, biomass, and tidal energy.

In addition to the teaching methods mentioned thus far, guest speakers from industrial firms, other university departments, governmental agencies, and other operating facilities have been invited to talk to the students, and field trips have been taken to solar research houses and industrial plants with effective energy management programs. At times, panel discussions have been arranged and some demonstrations of equipment for use in energy audits have been made. Students are encouraged to monitor current newspapers, magazines and television programs and to report current energy news in class.

Student Evaluations of the Course

In the eight classes taught to date, the enrollment has averaged 17 students, mostly graduates, with approximately half from the College of Business Administration, one fourth from Engineering and the others from Liberal Arts, Education, Home Economics, Urban Planning, and Law. The response of students has generally been favorable to the content and teaching methods used in the course. They like the practical orientation of the course and the timeliness of the topics. Few courses offer such an opportunity to discuss fast-breaking national and international developments almost every week. The broad scope of the course provides a good perspective of a complex, multifaceted subject and this type of overview was appreciated. The variety of activities and speakers were welcome and students especially enjoyed the vigorous arguments between members of the faculty when we taught as a team. The energy audit project was the highlight of the course and most students considered it invaluable for providing a real feel for managing energy and for sensitizing them to the important energy variables in operating systems.

On the other hand, some felt the wide variety of topics were discussed too superficially, and many felt their background knowledge was too limited in either engineering or financial analysis. The team teaching effort resulted in some lack of continuity and integration and produced a disjointed, spliced course at times. However, one person has been responsible for teaching the last five classes, and a single instructor lacks the depth of knowledge on many subjects which the team provided.

Overall, the students thought the course was very worthwhile and they gained new knowledge, analytical skills, a broader perspective, and a greater respect for various viewpoints on energy issues. They recognized the complexity of energy problems, the lack of quick fixes, and the need for careful energy managment to reduce energy consumption and the need for research studies to provide a sounder basis for future energy decisions.

Resulting Educational Materials and Activities

As a result of the grant from ERDA to develop, teach, evaluate, and disseminate a university course on energy management, several things have been accomplished. They are explained briefly in the following paragraphs.

Approximately 150 students have been trained to date and the course has been established as a permanent graduate offering. The authors compiled their teaching materials into a basic textbook entitled *Energy Managment — Theory and Practice* which was published by Marcel Dekker, Inc. of New York in 1980.

Additional grants were obtained from the Department of Energy to conduct workshops on energy education for high school teachers in 1979 and 1981. Teachers from the first workshop have become resource persons on energy to help others in local teacher training programs.

An energy film was produced on campus and in the community which was entitled "Aggressive Energy Management." It used humor, comic routines, cartoons, live commentaries, and factory scenes to project the need for energy conservation and ways to conduct an energy audit.

A one-day conference was held in 1976 for teachers of energy-related courses in several U.S. universities to share ideas and teaching approaches.

Energy audits have been conducted in approximately 50 local establishments and written reports have been provided to the manager of each one to assist them in their energy conservation efforts.

Several students have been employed in energy management jobs and four doctoral students have conducted energy-related research studies.

Finally, the faculty members who developed the course have spoken on energy topics at numerous local meetings and at some professional meetings.

All in all, it has been an interesting and challenging endeavor and one that I think should be repeated in other schools and nations.

4.3

TECHNICAL ENERGY EDUCATION FOR THE NON-TECHNICAL STUDENT

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Abstract

In the past decade energy, its price and its availability have become increasingly more important to the general population. All people need some knowledge of the technical limitations on fuel production, energy conversion, pollution control, new energy source development, etc., to avoid unrealistic expectations and to make appropriate decisions concerning energy use. Since 1973, The University of Central Florida has offered a course, Energy and Man, which introduces non-technical students to energy generation methods. The course is part of the university's advanced general studies program which requires all degree seeking students to take several courses outside of the college of their major.

Energy and Man is generally populated by undergraduate students seeking degrees in Business, Education, Health, Humanities, Natural Sciences and Social Sciences and by part-time students (usually employed full-time) who may not be degree seeking. The course has been developed to meet the needs of both groups of students.

This paper addresses the problems in presenting very technical material to non-technically oriented audiences and the methods which have been developed to successfully transmit this important information to this type of student body.

Introduction

The College of Engineering at the University of Central Florida offers a series of courses designed to be elective courses for undergraduate students majoring in non-technical disciplines. One of the major purposes of these courses is to provide knowledge that will enable UCF graduates with non-technical careers to more fully function and contribute in our technological society. A secondary purpose of these courses is to make students majoring in non-technical disciplines aware of engineering approaches to, and techniques for, problem solving so that communications between technical and non-technical people involved in decision-making processes will be facilitated. One of the major courses is these offerings is EGN 4824, Energy and Man, which has enrolled approximately 5,000 students since it was initially offered in 1973. The course is currently a University-wide elective offering having no prerequisites other than upper division standing; the University has the current capability of enrolling approximately 1,000 per year in Energy and Man in various sections on its main campus and at its satellite campuses.

Student Body

The University has a main campus in Orlando which is essentially traditional with the majority of students entering either from high school or from community colleges. There are also several satellite campuses which offer primarily evening courses and the students are typically older and pursuing or continuing education on a part-time basis. Energy and Man is offered in both environments and therefore has two distinctly different types of student body.

Regular Undergraduate

On the main campus the course is typically taught in large auditorium-type classrooms and has had enrollments as large as 300 students per section. The students are a cross-section of the University with students from the Colleges of Arts & Sciences, Business, Education, and Health with about 40% from Arts and Science, 40% from Business, 10% from Education and 5% from Health.
The course is intended to be upper level, that is, for Juniors and Seniors. However, a small number of freshmen and sophomores also enroll in the course.

The majority of the students do not have a strong background in mathematics and many are frightened of any numerical problem.

Continuing Education and Part-Time Students

Although almost all of the students enrolled in Energy and Man at the UCF satellite campuses are degree-seeking students also, they form a much more diversified group than those at the main campus. Some are recent high school graduates who are full-time students pursuing degrees at the satellite campuses because of the proximity to their families homes. Most, however, are part-time students who attend classes in addition to holding full-time jobs. This second group is divided into three distinct subgroups: 1) those not holding a degree, but progressing toward a degree to enhance their positions in the job market, 2) those already holding a degree, but pursuing a second degree in order to change career fields, and 3) those non-degree seeking students who wish to broaden their knowledge of the subject of energy.

The first sub-group comprises by far the majority of students enrolled in Energy and Man at the satellite campuses. Many of them own their own home, or have plans to, and want specific information on energy use in the home so that they can make decisions on materials to use, appliances to buy, etc., so that future perturbation in energy supply and pricing will have minimum impact on their lifestyles. Almost all of the students at the satellite campuses expect Energy and Man to provide them with an understanding of what is *really* happening on the energy scene in light of the many conflicting incomplete presentations in the media. As the main campus, most satellite students do no have a sufficient background in mathematics to permit the traditional engineering approach to such a course, but many are willing to endure mathematics if it will provide them with understandable answers to personal energy problems.

Development of Course

There are several imposed boundary conditions which have dictated how the course is generally taught. These conditions include: large section sizes, diversity of student backgrounds and general apprehension of mathematics.
With these constraints in mind, it is necessary to determine the goals for the course. For example, do we want to teach the first and second laws of Thermodynamics, or do we want to understand that any energy conversion device obeys rational laws and that "you can't get something for nothing...". The major goals for Energy and Man are fostering a greater understanding of energy resources production, distribution, use and conservation. These major goals are broken down into smaller ones: such as showing how the students own energy use patterns contribute to the over-all national energy situation, explaining energy measurement in kilowatt-hours so that the student's home electric meter reading has meaning, discussing home energy conversation measures, discussing economics and environmental impact of various methods of energy conversion, etc.

Course Topics

The topics that are generally included in the course typically include:

- Energy and Power: Definition and Units
- Uses of Energy: Domestic, Commercial Industrial, Agricultural, Transporation
- Depletable Sources of Energy: Coal, Oil, Gas, Uranium
- Non-Depletable Sources: Solar, Nuclear Breeding, Nuclear Fusion.
- Thermodynamics Laws: First and Second Laws, Efficiency.
- Generation of Electric Power: Hydroelectric, Fossil Steam, Nuclear Steam, Miscellaneous Sources.
- Future Power Sources:
- Calculation of Energy Costs:
- Energy and the Home: Insulation and R Values, Solar Considerations, Electric Meters, Conservation Measures.

Not all faculty will cover the same topics or cover them in the same detail but the list is fairly representative.

Depth of Coverage
Since Energy and Man is a survey course and deals with a large number of topics, it is not possible to cover any topic in great detail.

For a typical energy conversion process the student is expected to know the major pieces of hardware that are required, the types of energy conversion that occur, the limitations on the conversions imposed by the 1st and 2nd law of thermodynamics, the approximate cost of the conversion process, the availability of the fuel resource to supply the process, and the advantages and disadvantages of the process compared to other processes. For example, consider a fossil-fueled electric generating station. The student would be expected to know that the major facilities required include a furnace, turbine-generator, condenser and pump. He would be expected to know that the stored interanl energy of the fuel input is converted to heat in the furnace, the heat converted to internal energy of the steam, the internal energy of the steam converted to electrical energy output of the generator; that the efficiency of these conversion processes is limited by the Carnot thermodynamic efficiency and to calculate the Carnot efficiency given maximum and minimum temperatures. He should be able to determine how much fuel is required to generate a KWH of electricity and the fuel requirements for full operation of the plant. He should have a rough idea of the size of a power plant and the present construction costs per kilowatt of capacity.

Texts
It is important to have a textbook that is acceptable to all faculty and is understandable to the non-technical student. For the past several years we have used "Energy and Society" by Timothy Healy (Boyd and Fraser, 1976). For the 1980-81 academic year a compilation of handouts, articles and other information which supplements the text was assembled together in a course syllabus which was sold in the University bookstore at a modest price.

Over the past decade, there have been many other books published which might be considered as course texts and a general listing is given in Table I. Some of these texts are "soft" (i.e., little or no arithmetic or quantitative concepts) while others are "hard."

Presentation Methods
The principal presentation has been instructors lectures utilizing as visual aids either prepared 35 mm slides or overhead projector transparencies. Since the subject of energy is quite technical and engineering faculty are prone to be highly mathematical in their lectures, it is very important to be conscious of the background of the students and to develop lectures and visual aids which are understandable.
Numerical analogies are important, comparing dimensions with familiar quantities such as football fields, widths of roads, heights of buildings, etc. Comparisons of growth parameters can be made with biological examples (most students have had some biology) and also with other daily examples such as the number of hamburgers sold by McDonalds, etc. A sense of humor is an important teaching quality for this type of course. In addition, comparisons of energy and resources to income, assets, and expenses is also successful. For example, the first law of thermodynamics may be explained by a financial analog where the various forms of stored energy (internal, potential, kinetic, etc.) are like the balance in savings and checking accounts and the transient energies (heat and work) are like deposits and/or withdrawals. Energy transformations can then be compared with financial transactions which change the balances in the various accounts. Similarly the second law of thermodynamics can be explained by an analogy to brokerage or commission charges which can never be eliminated completely. Sometimes one can personalize the discussions such as figuring the student's own light bill, gas mileage, water use, etc. There is no fixed formula and faculty develop their own style and techniques for introducing mathematical manipulation, most with gratifying results.

Encouraged by this approach to communicating important information to a concerned audience, participating faculty members have also prepared carefully formulated examples that expose the students to the thought processes involved in engineering analysis, including how mathematics and the principles of science are used as tools.

To enhance student interest, increase their ability to understand the material, and expose them to a broader spectrum of informed opinion, it is frequently desireable to use presentation techniques beyond the text and the instructor's lectures. Such supplemental presentations include motion pictures, invited guest lecturers, and demonstrations. Students are generally held responsible for material contained in these supplemental presentations. Term papers, article abstracts and student panels can be used in smaller classes and shared with the entire class.

Many excellent motion pictures have been obtained which provide exposure and insights into subjects and processes that are highly technical but are explained in non-technical terms and using mathematical comparisons that are generally understandable to a non-technical oriented audience. Since students are held responsible for the material it is helpful to provide them with an outline and study questions before showing a film on which they can make notes while the film is showing. It is also desireable to have some method to allow students who miss a film to view it on their own time.

Guest speakers help broaden the perspective of the students. Guest speakers have included representatives from energy industries (oil companies, nuclear development), utilities and government agencies. Other faculty who have particular expertise in areas as energy conservation, oil and gas production, economics and regulation, etc., have also been used as guest speakers.

Demonstrations can give the students a better mental image than photographs. Effective demonstrations have ranged from a pill that is the approximate size of a nuclear fuel pellet, to a solar collector system or an analog computer simulation of the total energy situation and strategies to match supply and demand.

Course Evaluation
Several methods have been used to evaluate the effectiveness of the course and the students perception of its value to them.

An "attitudinal survey" has been developed and administered at the beginning and end of the term to evaluate how students attitudes toward energy issues have changed as a result of taking the course. The results of this survey have indicated that the students have attained a generally more realistic appreciation of the technological limitations and problems in energy use and development. On the other hand, the opinion on what could be considered the moral and ethical aspects of energy were not significantly changed. For example, at the start of the course 56% felt that oil shale would solve our crude oil problems while at the end of the course only 24% felt this to be true. At the beginning of the course 58% felt the U.S. should militarily protect its foreign oil interests and 13% felt we should not. At the end of the course 55% felt we should and 16% felt we should not.

The University has a formal system of instructor evaluation by students which also allows the students the opportunity to comment positively and negatively about the course. In this system student reactions have ranged from highly favorable to highly unfavorable. The majority of students seem to react favorably to the material presented in the course but many dislike the use of any arithmetic.

The favorable responses from students indicate they consider the course material important, and that it will enable them to use energy wisely and allow them to participate in discussions or debates as well as vote on energy matters more intelligently. Some have even staed that the material is so important that the course should be required, not just elective.

The more typical responses indicate that the students feel they have learned something of value, that they will try to be wise consumers, and that they can now follow discussions on energy policy and energy developments with some discernment. The negative responses usually indicate they were overwhelmed by the arithmetic and they felt the course was too technical for non-engineering majors. Another general negative response is that the students dislike the very large class (up to 300 students) and feel they don't have adequate opporunity to ask questions or participate.

Students generally like the inclusion of outside guest speakers. The students then realize that some of the topics discussed are important in the "real world" outside the classroom. Students thus gain an appreciation that the energy crisis is real, energy concerns are important, and decisions about nuclear power and alternative energy sources, for instance, cannot be made without considering the entire energy question. They learn that personal conservation can help, but that there are no simple solutions to the problem, technical, social, economic or political.

Additional evaluation of students perception of the course is obtained informally from one-on-one discussions with students. Comments are generally favorable, probably reflecting a "be nice to the instructor" syndrome rather than what the student may acutally feel.

Evaluation (Grading)

For the larger sections, most grading is done by computer-graded, multiple-choice objective examinations. Students can be given study questions to assist them in reviewing the topics of importance. Smaller sections might employ essay questions, along with the multiple choice. In smaller sections it is also possible to assign a variety of homework topics such as short papers, article abstracts, student panels, or other similar assignments. In assigning papers or article abstracts, it is important to indicate to the students the national publications and other sources with which they might not be familiar. Although most are familiar with national newspapers and newsmagazines (although they had perhaps rarely looked at the Science/Technology sections), many are not as familiar with *Scientific American. Technology Review. Science 80,* and other more technically oriented sources. Some faculty give very specific guidance to the students, and also exclude the various "gee-whiz" magazines which tend to be somewhat superficial and non-technical in energy-related articles.

Student evaluation is always a sensitive subject. It is of primary importance that whatever the techniques used the testing or evaluation be fair and equitable, with a minimum of ambiguity. This imposes another challenge for the instructor.

FACULTY

Faculty Reactions

The general reaction of the faculty instructors is positive, most viewing it as an opportunity to expose an important audience to the technical problems and important energy issues confronting civilization. In spite of course sections containing large enrollments, spirited discussions often begin in class and continue after class in hallways and faculty offices. Such positive exchanges result in much enthusiasm by faculty and students.

Faculty generally used to teaching technical material to a mathematically inclined audience are frequently dismayed and frustrated by students who consider algebra as "advanced mathematics." Successful faculty accept this aspect as a challenge: to present the material quantitatively enough to satisfy the instructor's sensibilities, but not so mathematically that for the students this kernal message sinks in a sea of numbers. As discussed earlier, this challenge is most successfully met by using analogies which are familiar to the student's experience.

Administrative Support

It is extremely important that there be administrative and institutional support for these courses. Faculty soon realize that preparing for this type of course (whether the enrollment is 40 or 200) is different than for more quantitative engineering courses. The visual aids, previously mentioned, are very important. The internal reward structure with regard to promotion, tenure, and annual evaluations must not penalize faculty interested in teaching this course or others similar to it. If there is no administrative support, morally and physically, then dynamic young faculty will not get involved.

It is also important that faculty not be imposed upon by being repeatedly assigned to courses of this type without other avenues for professional development, research and growth. Currently the College of Engineering tries to schedule an individual faculty member to this course no more than 2 out of 4 quarters per year, although some will teach a section almost every quarter.

Conclusions

Energy and Man, a course offered by the College of Engineering at the University of Central Florida, has provided a vehicle for students majoring in non-technical disciplines to be exposed to engineering methods of problem solving while learning about the broad issues of energy. Student enrollment in and reaction to the course indicate that Energy and Man meets a generally perceived need in the student body. These students are thus better prepared for meaningful participation in a technological society.

TABLE I

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4.4

A GRADUATE INTERDISCIPLINARY CURRICULUM IN ENERGY STUDIES

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Abstract

A Master's level curriculum called Energy Studies has been developed utilizing a broad interdisciplinary approach which is under administrative supervision of the Sangamon State University's Innovative and Experimental Studies Cluster. It is a graduate level program designed to supplement and expand upon a discipline-based bachelor's degree. Students may pursue a graduate degree in this field of study through either the Individual Option Program or the Environmental Studies Program.

The goal of Energy Studies is to synthesize technical knowledge and social considerations. The complexities of the energy problems which face out society demand that the student develop this wide spectrum of knowledge. The Energy Studies Program, therefore, utilizes resources from several disciplines, including: Administration, Economics, Environmental Studies, Legal Studies, Sociology, Education, and the Natural Sciences in addition to courses specifically designed for Energy Studies. Faculty from these disciplines are brought together to aid the student in developing a full understanding of this complex subject.

There are also several active research projects in which students may participate for academic credit. These projects include: Community Energy Self-Reliance for Springfield; various topics in solar energy; legal issues of nuclear power; Midwest Community Energy Newsletter, Sangamon River Basin Program. Students are also encouraged to initiate their own research topics.

The response to this program, initiated 3 years ago, has been very positive. Currently, about 25 courses are offered and student enrollment is high. The problems associated with such a program will also be discussed.

4.5

AN INTERDISCIPLINARY PROGRAM ON ENERGY POLICY

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Abstract

As an outgrowth of several years experience in teaching a course on the science and technology of energy we have initiated at SMU an interdisciplinary course entitled "Energy and Public Policy." A colleague from our Political Science Department (P. Melanson), who is a specialist in public policy, and I plan to offer the course during the 1981-82 academic year.

The course is intended for about twenty juniors and seniors having only a non-specialist's background in both physical and political sciences. It will begin with a series of background lectures and readings on the physical principles which underlie the development and maintenance of major present and future energy technologies. Similar presentations on the history and practice of public policy in non-energy areas will also be offered. These background-building efforts will occupy the first third of the semester.

In the second third of the course teams of three or four students will prepare seminar topics for presentation to the entire group. These topics will be more specifically related to energy policy dealing with areas such as social organization and energy use, environmental protection policy, and the role of government incentives and subsides in energy development.

Finally, during the last third of the course student teams will investigate and prepare reports on energy policy issues having local implications. These studies will include contacts with university, municipal, state, and regional officials involved in the development and administration of energy policies.

SESSION 5:

5.1

A RESOURCE UNIT FOR TEACHING ENERGY
TO ELEMENTARY SCHOOL STUDENTS

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TABLE OF CONTENTS

Abstract

This paper outlines the content for an energy curriculum. Concepts related to the energy topics in the outline and processof of science appropriate for elementary activities are included. In addition, a rationale for selecting the grade levels at which children are capable of learning specific concepts and conducting specific processes is provided.

Text

Strands from three theories were brought to focus on energy concepts in the development of this resource unit on energy for teachers of grades K-6. These theories are: Gagne's Theory on the Varieties of Learning, The Processes of Science formulated by the American Association for the Advancement of Science Commission on Science Education, and Piaget's Theory of Cognitive Development.

First, I will briefly discuss Gagne's Varieties of Learning. Gagne proposes that learning can be classified as: Verbal Information, Cognitive Strategies, Attitudes, Motor Skills, and Intellectual Skills. The latter type of learning can be subdivided into five categories which are hierarchical: beginning with Discriminations, proceeding to Concrete Concepts, Defined Concepts, Rules, and finally, Problem Solving.[1] Gagne's theory provides a two-pronged attack on the problem of instruction. Frequently teachers initiate their instruction on a topic by selecting tasks for the students. Using Gagne's theory a learning task can be analyzed to determine which type of learning is required for the student to complete the task. This helps make the teacher more aware of the degree of difficulty of the task. A second way to approach instruction on a topic is for the teacher to decide the type of learning he wants students to attain. Then he selects tasks and provides the conditions that facilitate the particular variety of learning selected.[2]

In the development of this unit of energy, Gagne's Theory was applied after the list of concepts had been generated. Each concept was analyzed to determine the types of tasks that elementary students could perform to learn the topic. For some topics it was decided that elementary students could distinguish between objects or events related to the topic, that is, they could make Discriminations. For other topics it was believed that elementary students could learn the concept as a concept, either a Concrete or Defined Concept, could understand the relationship of the concepts to other concepts in a Rule, and perhaps could even apply the Rules in an unfamiliar setting, that is, Problem Solving. In the case of these topics the children would be using Intellectual Skills. In the case of other topics it was believed that elementary students could only memorize facts or definitions. These topics would be learned as Verbal Information. The children would not be able to process this information or use the information to reason or to apply it in new situations. For the list of concepts and the varieties of learning each concept requires, see Appendix B.

The second strand that was used in developing the curriculum was the Processes of Science. The processes that scientists engage in when investigating natural phenomena have been described by the American Association for the Advancement of Science Commission on Science Education as consisting of eight Basic and five Integrated Processes. The eight Basic Processes of Science are: Observing, Using Space/Time Relationships, Classifying, Measuring, Using Numbers, Communicating, Inferring, and Predicting. The five Integrated Processes combine two or more of the Basic Processes. These processes are: Controlling Variables, Interpreting Data, Defining Operationally, Formulating Hypotheses, and Experimenting.[3] These processes are the focus of an elementary scienc program developed by the American Association for the Advancement of Science and published by Ginn and Company.[4] In this program activities intended for the primary grades use only the Basic Processes. Gradually, as children in the middle grades become accustomed to using the basic processes, the integrated processes are introduced. By the time the child has completed five to six years using the basic and integrated processes he is ready for the culminating Integrated Process, the process that includes all the other processes — Experimenting.

The third theory that underlies the rationale for this curriculum is Piaget's Theory of Cognitive Development. This theory states that intellectual development can be divided into four major periods: Sensorimotor (birth to 2 years), Preoperational (2 to 7 years), Concrete Operational (7 to 11 years), and Formal Operational (11 years and above). Each period is characterized by certain ways of thinking.[5] As children progress through each stage they exhibit patterns of reasoning characteristic of that stage. Most children in elementary schools are in the concrete stage of cognitive development. Children in this period of cognitive development demonstrate the ability to conserve, to serial order, to do simple classifications, to take the role of others, to reverse their thinking, and to think logically about familiar concrete phenomena with which they have direct experience.[6] Children in this period of intellectual development need sensory experiences and should be encouraged to follow their natural curiousity in observing the world around them.

When selecting concepts to be studied at a particular grade level, consideration should be given to:

1. The concept that is the focus of the learning.
2. The Processes of Science that will be used in the instructional activity.
3. The Type of Learning that the teacher expects the child to acquire on the topic.
4. The Stage of Cognitive Development of the child.

The product of the first three areas of consideration enumerated above is the instructional material, that is, the lesson plan. The fourth area enumerated above allows one to decide an appropriate grade level for implementing the lesson.

Piaget's Theory of Cognitive Development provides a rationale for analyzing the nature of the concepts:

* Can the concept be understood using concrete reasoning patterns or are patterns of reasoning characteristic of the formal operational stage required?
* If the concept is abstract, is it possible for a person to learn something about the concept using concrete means? (For example, electric circuits or temperature). Or must abstract reasoning or models be used to acquire an understanding of the concept? (For example, Kinetic molecular theory or model of the atom).

The Processes of Science can also be examined using Piaget's theory to determine the level of cognitive development required to perform the process:

* Is the object or event that is the focus of the process from the child's familiar environment?
* Does the process require the student to use reasoning patterns characteristic of a child at the concrete operational stage of cognitive development or at the formal operational stage?
* Most of the Basic Processes involve sensory input and can be performed by children at the concrete stage of cognitive development. For example, Observing, Using Space/Time Relationships, Classifying, Measuring, Using Numbers, Communicating, can all focus on concrete experiences. Inferring and Predicting usually require some abstract reasoning.
* The Integrated Processes usually require reasoning skills characteristic of students in the Formal Operational Stage of Cognitive Development.

In making the decision which of Gagne's Varieties of Learning would be most appropirate for elementary school children to learn a specific topic, Piaget's Theory of Cognitive Development provided a basis for asking questions such as:

* Do the discriminations students make between objects or events require only sensory input?
* Is the concept a concrete phenomenon?
* Is the student required to identify concrete examples of the concept?
* Is the student required to understand a definition of the concept?
* Is it necessary for the student to understand the relationship between two defined concepts in order to use a rule?
* Is the student expected to select which rule to use in solving a particular problem?
* What kind of reasoning skills will the student have to use to solve a particular problem?

The task that the child is expected to be able to do to indicate that he has acquired the specific learning must be evaluated in terms of its appropriateness for children who are in the concrete stage of cognitive development. Sensory discriminations and concepts of concrete phenomena are suitable for such children. Defined concepts may be appropriate if the definition can be learned through concrete experiences. Rules and Problem Solving tasks that require the child to use concepts that he has learned using concrete media are also appropriate. If concepts that can only be learned using models and/or abstract reasoning are studied, children at the concrete stage of reasoning will cope by memorizing. While it is useful to have children learn some facts in this manner, real learning is much more than rote memorization of facts. It is being able to understand the facts and relate a new learning to what has previously been learned.

Some topics related to energy are appropriate for children who are in the Concrete Stage of Cognitive Development. For example:

* Discriminating between stored or moving energy.
* Identifying the Forms of Energy being demonstrated.
* Classifying examples of energy according to the Form of Energy.
* Demonstrating the transfer of stored energy to energy of motion.

Each of these topics can be taught by providing the children with direct concrete experiences. Topics which can be taught using concrete experiences can be learned at the level of Itellectual Skills. Topics which require the understanding of models, such as atomic theory, are inappropriate for children in the Concrete Stage of Cognitive Development. Most children in grades K-6 could learn about atomic energy only at the Verbal Information level. They would only be able to memorize facts about the topic.

When using these guidelines one must remember that these are intended for the "average" child. Children vary greatly as to the age they acquire an ability to reason concretely or abstractly. The child's prior experience with the topic greatly influences his ability to understand the concept. If a concrete concept exists for a topic it is helpful to provide experiences to help the child acquire a concept for the same phenomenon. The dividing line between Stages is not abrupt. Children go through a Transitional Stage as they progress from one stage to the next. In a Transitional Stage a child exhibits patterns of reasoning characteristic of both the stage he is leaving and the stage he is entering.

The following procedure was followed when developing this curriculum.

1. An outline of the major topics and sub-topics was developed. See Appendix A.
2. Concepts relating to each topic were generated. See Appendix B.
3. The Type of Learning at which elementary school aged children would be capable of learning each concept was determined. See Appendix B.
4. The Processes of Science that could be used in activities to facilitate the learning of each concept were identified. See Appendix C.
5. A list of behaviors that a student could be expected to demonstrate after completing the unit was generated and classified using Gagne's Types of Learning. See Appendix D.
6. For each sub-topic the following procedure will be followed:
   a. Performance Objectives will be formulated.
   b. The test item or activity that will be used to assess the student's performance of the task specified in the objective will be constructed.
   c. Activities that could be used to facilitate student's learning the concept will be developed or selected from existing curriculum programs.
   d. A list of resource materials will be generated.

NOTE: This part of the curriculum is still under development. See Appendix E.

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Appendix A - Outline of Unit: Energy[7]

I. What is Energy
- A. Definition
- B. Types of Energy
  1. Stored (Potential)
  2. Moving (Kinetic)
- C. Forms of Energy
  1. Sound
  2. Heat
  3. Light
  4. Mechanical
  5. Chemical
  6. Electrical
  7. Atomic
- D. Transfer of Energy
- E. (Interconversion of Matter and Energy)

II. Sources of Energy
- A. Renewable
  1. Solar
  2. Wind
  3. Hydropower
  4. Biomass
- B. Non-Renewable
  1. Fossil Fuels
  2. Nuclear
  3. Geothermal

III. Uses of Energy
A. Natural
1. Biological
2. Physical
B. Technological
1. Factors That Affect Energy Usage
a. Social
b. Economical
2. Consequence of Energy Usage
a. Social
b. Economical
c. Environmental

IV. Problems Related to Energy
A. Social
B. Economical
C. Environmental

V. Conservation of Energy
A. Distribution
B. Demand
C. Alternative Energy Sources

Appendix B — List of Energy Topics and Concepts and the Variety of Learning Appropriate for Teaching Concepts to Elementary School Children

Topic	Concepts	Type of Learning
I. What is Energy:		
A. Definition:	Energy is the ability to do work.	Information Defined concept
B. Types of Energy:	Energy can be stored or moving.	Information Discrimination Concrete Concept
C. Forms of Energy	Energy exists in many forms: sound, heat, light, mechanical, chemical, electrical, and atomic.	Information Discrimination Concrete Concept Defined concept
D. Transfer of Energy	Energy can be converted from one form to another. No energy is lost or gained in ordinary reactions. With each change some energy become unavailable for use.	Information Discrimination Concrete Concept Defined Concept Rule Problem Solving
E. Interconversion of Matter and Energy	Energy can be changed into matter and matter into energy ($E=mc^2$).	Information
II. Sources of Energy:		
A. Renewable:	* Some energy sources are essentially limitless.	Information Discrimination Concrete Concept Defined concept Rule Problem Solving
1. Solar	* The sun is the primary source of energy on earth. The sun provides us with heat and light. The sun causes winds and tides. Light from the sun is necessary to produce the energy in food. Light can be used to produce electricity.	Information Concrete concept Defined concept
2. Wind	* Wind is caused by the sun heating the air. * Wind can be used to generate electrical and mechanical energy.	Information Concrete Concept Defined Concept Rule Problem Solving
3. Hydropower	* Hydropower results from the effect of the sun's heat on water.	Information Defined Concept Rule

	• Hydropower can be used to generate electricity and mechanical power.	Problem Solving
4. Biomass	• Energy stored in plants is a potential supplemental fuel. • Biomass is any form of plant material. • Biomass has about ½ the stored energy of coal.	Information Concrete Concept Defined Concept
B. Non-Renewable:	• Some energy sources can not be replaced.	Information Discrimination Concrete Concept Defined Concept
1. Fossil Fuels	• Peat, coal, oil, and natural gas are fossil fuels. • Fossil fuels were formed million of years ago from decaying plants and animals. • People depend on burning fossil fuel to heat their homes and to run machinery. • Coal is often used to produce electricity. • The supply of fossil fuels is limited. • A by-product of burning fossil fuels is environmental pollution.	Information Information Defined Concept Information Concrete Concept Defined Concept Information Information Information Concrete Concept
2. Nuclear	• Nuclear Energy is produced by the conversion of matter into energy. • Two types of Nuclear Energy are: Fusion or putting small molecules together and Fission or breaking apart large molecules with the release of energy.	Information Information
3. Geothermal	• The earth's heat is a potentially valuable source of energy. • Geothermal Resources include steam, hot water, and hot rock. • Heat from the earth could be used to generate electricity.	Information Concrete concept
III. Uses of Energy: A. Natural. 1. Biological 2. Physical	• Energy is required for growth, movement, and change. • Energy is needed to move a force through a distance.	Information Defined Concept Information Concrete Concept
B. Technological. 1. Factors That Affect Energy Usage 2. Consequences	• Energy usages vary according to a person's philosophy and life style, social customs, and the economy. • Energy conversions involve social and environmental costs. • Personal and Social choices affect the short and long term consequences of energy use. • Changes in energy usage alter life style. • New energy technology is being developed.	Information Discrimination Defined concepts Attitudes
IV. Problems Related to Energy A. Social. B. Economical. C. Environment.	• Society is dependent upon energy • Energy is a major factor in our economy. • Energy source have different impact on the environment. • Burning Fossil Fuel causes environmental pollution. • Nuclear reactions produce radio activity	Information Concrete Concept Defined Concept
V. Conservation of Energy	• Each individual/group has a responsibility to practice energy conservation.	Attitude
A. Distribution.	• Energy resources are limited and are	Information

	unevenly distributed around the earth	
B. Demand.	* There is a growing imbalance between the availability of and the demand for energy.	Concrete Concept Information
C. Alternative Energy Resources.	* The imbalance between availability and the demand for energy necessitates the development of alternate energy resources	Information Attitude Problem Solving

Appendix C — List of Energy Topics with the Processes of Science that Could Be Used to Teach the Concepts to Elementary School Children

Outline	Processes of Science
I. What Is Energy?	
A. Definition.	Observing, Using Space/Time Relationships
B. Types.	Observing, Using Space/Time Relationships, Classifying
C. Forms.	Observing, Using Space/Time Relationships, Classifying
D. Transfer of Energy.	Observing, Using Space/Time Relationships, Classifying, Measuring, Using Numbers, Communicating, Inferring, Predicting, Controlling Variables
E. (Interconversion of Matter and Energy).	——
II. Sources of Energy.	
A. Renewable. 1. Solar. 2. Wind. 3. Hydropower. 4. Biomass. B. Non-Renewable. 1. Fossil Fuels.	Observing Using Space/Time Relationships Classifying Measuring Using Numbers Communicating Inferring Predicting Controlling Variables Interpreting Data Defining Operationally Formulating Hypotheses Experimenting
2. Nuclear.	——
3. Geothermal.	——
III. Uses of Energy.	
A. Natural. 1. Biological. 2. Physical. B. Technological. 1. Factors that Affect Energy Usage. 2. Consequences.	Observing Using Space/Time Relationships Classifying Measuring Using Numbers. Communicating Inferring Predicting Controlling Variables Interpreting Data Defining Operationally Formulating Hypotheses Experimenting
IV. Problems Related to Energy. A. Social B. Economical. C. Environmental.	Observing Using Space/Time Relationships Classifying Measuring Using Numbers Communicating Inferring Predicting Controlling Variables Interpreting Data Defining Operationally Formulating Hypotheses Experimenting

V. Conservation of Energy.
  A. Distribution.
  B. Demand.
  C. Alternative Energy Resources.

Observing
Using Space/Time Relationships
Classifying
Measuring
Using Numbers
Communicating
Inferring
Predicting
Controlling Variables
Interpreting Data
Defining Operationally
Formulating Hypotheses
Experimenting

Appendix D — List of Behaviors Classified by Variety of Learning that a Student Could be Expected to Attain Upon Completing the Curriculum on Energy.

Intellectual Skill: Discrimination
The student will:

- discriminate between instances when objects posses stored energy (potential) and when objects possess moving energy (kinetic).
- discriminate between forms of energy.
- distinguish situations in which energy is being transferred from one form to another from those in which there is no transfer of energy.

Intellectual Skill: Concrete Concepts
The student will:

- identify objects that possess stored or moving energy.
- identify the form of energy demonstrated.
- identify situations in which energy transfer is occurring.
- point our illustrations of renewable and non-renewable energy resources.
- identify pictures that illustrate the sun, wind, or water as an energy source.
- point out pictures from magazines that illustrate how a person's life style affects the amount of energy he uses.
- identify illustrations that show a high dependance on energy.
- point out on a globe or map showing the distribution of natural resources geographical areas that have a large supply of coal or oil.

Intellectual Skill: Defined Concepts
The student will:

- classify examples of energy according to its form.
- demonstrate the definition of energy.
- classify sources of energy as renewable or non-renewable.
- explain the transformation of the chemical energy stored in food to heat and motion in the body.
- categorize pictures into groups having a high or low energy requirement on the basis of the life style represented in the picture.
- categorize pictures into groups having a high or low energy requirement on the basis of the level of technology of the society that is pictured.

Intellectual Skill: Rules
The student will:

- demonstrate the transfer of stored energy to energy of motion.
- demonstrate the transfer of energy of motion to stored energy.
- demonstrate a situation involving the transfer of energy such as the transfer of:
  wind energy to mechanical energy.
  water energy to mechanical energy.
  mechanical energy to electrical energy.
  chemical energy to heat energy.
  heat energy to water energy.
  heat energy to wind energy.
  electrical energy to heat energy.
  electrical energy to light energy.

Intellectual Skill: Problem Solving
The student will:

- generate a solution to a problem situation involving selection of an energy source, energy usage, and energy conservation.
- design a working model of a house heated by solar energy.
- create a device for converting the energy from a renewable source to mechanical energy.

Cognitive Strategies

The student will:

* draw upon his prior learnings, as well as the concepts and skills learned in this unit, to develop a plan for solving one of the following problems:
    * Create a device for converting a renewable energy resource to mechanical energy.
    * Design a working model of a house heated by solar energy.
* outline his strategy for generating a solution to an environmental problem that requires for solution the selection of an energy source, energy usage, and energy conservation.

Verbal Information

The student will:

* state the definition for energy.
* name the two main classes energy can take - stored energy and moving energy.
* list seven forms of energy.
* state that energy can be transferred from one form of energy to another.
* state the rule for the interconversion of matter and energy ($E=mc^2$).
* define the terms *renewable and non-renewable energy resources.*
* list examples of renewable and non-renewable energy resources.
* list three reasons why the sun is the primary source of energy on earth.
* state the cause of wind.
* list two uses of wind power.
* state the cause of hydropower.
* list two uses of hydropower.
* define the term *biomass*.

* name three types of fossil fuels.
* state how fossil fuels were formed.
* list three examples of uses of fossil fuels.
* state how nuclear energy is formed.
* list two processes that release nuclear energy.
* define the term *geothermal energy.*
* list three types of geothermal resources.
* list three processes in living things that require energy.
* state the relationship between energy, a force, and a distance.
* list factors that affect energy usage.
* name one energy related problem in each of the following three areas of concern: social, economical, and environmental.
* name the geographic area in which specific energy resources are located.
* list alternative energy resources.
* list countries that have the greatest energy demands.

Attitudes

The student will:

* accept a change in his life style to reflect a decreased energy consumption.
* accept responsibility for conserving energy in his own life and sphere of activity.
* be willing to use alternative energy resources.
* choose to conserve electricity
  by turning off unnecessary electricl lights and by decreasing the amount of television watched.
* choose to walk rather than ride in a car when possible.
* choose to wear sweaters in the house and school when it is cold outside so that the thermostat can be lowered.
* choose to save aluminum cans and other items for recycling.
* organize friends to save items that can be recycled.
* organize an energy conservation group.

Appendix E - Examples of Objectives

1. Classes of Energy.
When presented with a moving pinwheel and examples of both moving (kinetic) and stored (potential) energy such as: a moving paddle wheel on a toy boat, an electric motor, a wind-up toy, a flashlight battery, a log, and a bar of chocolate, the student will discriminate the objects that have energy of motion from those that do not have energy of motion by pointing to the objects which are like the moving pinwheel when asked by the teacher.

2. Forms of Energy.
a. Wt en presented with the sound of a bell ringing, a light beam from a flashlight, a cup of hot water, a moving electric motor, and a log, and the terms for the following forms of energy: sound, heat, light, mechanical, chemical, electrical, the student will identify the form of energy each object has by pointing to the appropriate object as the teacher names each form of energy.
b. When presented with the sound of a bell ringing, a light beam from a flashlight, a cup of hot water, a moving electric motor, and a log, and the characteristics of the following forms of energy: sound, heat, light, mechanical, chemical and electrical, the student will classify each object or event by naming and defining the forms of energy being illustrated.

3. Transfer of Energy
Using a toy paddle boat and a rubber band, the student will demonstrate the transfer of stored energy in the rubber band to energy of motion in the paddle wheel by winding up the rubber band-paddle wheel mechanism and placing the toy boat in a tub of water when requested by the teacher.

5.2

ENERGY DAY: AN ELEMENTARY LEVEL ENERGY CURRICULUM

by Selma Sleven and Mimi S. Baer

Abstract
Energy can be characterized as a "push or a pull that makes things move." Beginning with this simple qualitative definition of energy, students and teachers at the St. Augustine School in Santa Monica, California designed a truly comprehensive elementary level energy program. Classes at each grade level selected a different form of energy to explore. All the children participated in an ENERGY DAY which was a culumination of the information they had collected about energy and energy alternatives. The major group projects that students at each level created to illustrate science ideas will be described, and the manner in which these ideas were intergrated into the general curriculum will be noted.

First Grade — Wind Energy

Topic selected
The demonstration of a milk carton water wheel led students to realize that a wheel moved by water could also be moved mechanically by hand and even by blowing across the wheel. Wind energy was selected for study. Since winds are the motion of molecules in gasses, two science ideas were developed: (1) the particulate nature of matter and (2) molecular condition and changes in the states of matter. A study of winds and weather culminated in group construction of a climb into thundercloud.

Projects for Presentation
Using a refrigerator carton and 2 washing machine cartons, the high hat shape of a cumulo-nimbus cloud was simulated. The cartons were then covered with painted paper to achieve the appropriate coloration. Traffic was routed through the cloud via a small doorway entrance and exit. Inside the black paper lined cloud, an ultraviolet light highlighted styrofoam hailstones, plastic wrap rain and flourescent paper lightening. Child-produced thunder was recorded and used, which integrated even the music department into teh energy day project.

Classroom Activities
The abstract idea that matter is made of molecules can be introduced on a first grade level by having each child tear a piece of paper into the smallest piece possible, and noting that this tiny section still contains hundreds of thousands of paper molecules. The interrelationship between the molecules determines the states of matter. Molecules in a solid can be said to be locked together giving the solid its definite shape. In liquids, molecules take on the shape of the container because they slip and slide over each other.

In gases, molecules bounce around like trillions of miniscule ping pong balls. Changes in state, therefore, can be characterized as the locking and unlocking of molecules, can be related to the water cycle, and can be illustrated by making candles. Since the rate of molecular movement varied, each child made a model of an anemometer to understand measurement of wind speed. In addition, each student built an energy converter, a simple windmill that uses wind energy to raise an object. This illustrated the concept of the conversion of wind energy to mechanical energy.

Curriculum Intergration
Ideas about energy in the wind and the production of weather predicting instruments was connected to work on myths, legends, story telling and poems about weather and winds.

Second Grade — Sound Energy

Topic selected
A general classroom study of animal communication was tied to the ENERGY theme through an investigation of sound energy. Sound is produced by vibrations and the mechanisms animals use to cause vibrations were studied. Contrasts between communities of animal with and without vocal cords were illustrated in an exhibit that included a hollow tree with a bee hive, a woodland scene and a pond. Sound energy as moving molecules and its production and function in communication was highlighted.

Project for Presentation
Students climbed into a refrigerator carton which they designed as a hollow tree. Inside, they hung egg carton honey combs and models of bees to create the impression of a bee hive. This carton was connected to two more refrigerator cartons which became a diorama of a woods scene, the bottom carton simulating an underground passageway.

Classroom activities
The nature of sound, the variations in method of producing vibrations, and animal communication were unified in the study of sound as a form of energy. Whatever vibrates causes molecules to move and the character of their movement determines the specific sound that is created. Activities that contrast and specify the character of sounds are effective in teaching sound energy.

Third Grade — Electrical Energy

Topic selected
The use and conservation of electricity was studied through the production by each student of a mini cardboard room in which a simple circuit operated.

Project for Presentation
Students mini rooms were coordinated into a large three dimensional bulletin board hotel aptly named "The Plug Inn" by the students.

Classroom Activities
At the third grade level, understanding of the vocabulary of electricity grew when body movement was incorporated into the description of current, voltage and resistance. Five children standing in a row, hands on hips, illustrated a current or the flow of electrons domino style from elbow to elbow. Voltage was illustrated by the intensity of the push that started the current flowing, and resistence by the rigidity of the next elbow. The path of an electric current was demonstrated via a circle of students who enabled the current to flow around.

Numbers of circuits encountered in everyday use were observed and conservation possibilities and ideas were disseminated on Energy Day.

Curriculum Integration
A classroom study of community was enhanced by observation of local energy practices and needs. Construction of mini rooms necessitated a focus of attention on detail by each student. Coordination of all rooms into a larger structure highlighted the need for common services.

Fourth Grade — Chemical Energy

Topic selected
Because the fourth graders were involved in weaving and dying fibers, they explored the chemical energy which is produced when molecules change partners.

Project for Presentation
To understand the nature of chemical changes and chemical energy, students investigated the structure of atoms and constructed marshmallow molecules. In addition, styrofoam squiggles were painted and grouped into a 3 dimensional model showing chemical changes. Students took turns using actual indicators, acids and bases to demonstrate chemical reactions to those who attended Energy Day.

Curriculum Integration
The study of chemical energy from a molecular standpoint made it possible for students to realize that similar reactions happen with different chemicals and that sometimes reactions can be violent. Similiarly, chemicals can co-exist and only react when energy is applied. The concepts of grouping materials by their properties and differentiating by observation definitely can be extended into the general curriculum in many areas.

Fifth and Sixth Grades
Measuring Energy and Energy Alternatives

Topic Selected
Comparisons of various kinds of pushes and pulls or alternative forms of energy led to questions of quantity and methods of measurement. Electric meters were constructed of cardboard and instructions for their use were compiled. Alternative forms of energy were sought imaginatively. The need for conservation of currently available supplies so as to permit time for development of new forms became clear. The problems and benefits of each form of energy were investigated and listed.

Projects for Presentation
Paper models of electric meters were constructed in quantity by the students for distribution to parents on Energy Day. Large charts listing the problems and benefits of various forms of energy were constructed and used by the students to describe these alternatives to visitors.

To demonstrate solar energy, each student constructed a cardboard and foil Solar Hot Dog Cooker. The limitations of solar power became obvious on Energy Day because the fog in Santa Monica left the hot dogs very raw.

Students measured the food energy in a peanut by constructing a calorimeter. Awareness of the complexity of the energy picture was recognized.

Curriculum Integration
Factors that must be considered in dealing with our energy problems in the future led to the development of a booklet that was compiled and distributed by the fifth and sixth graders, for the purpose of educating those less aware of our needs. The skills and concepts incorporated in an effort of this nature necessarily were drawn from many areas of the curriculum.

Conclusion
Armed with a more complete picture of our energy needs and problems, elementary level students can face the challenges of the future with a firmer footing on which to build. Conservation alone is not a complete answer, but neither is total reliance on systems which as yet are limited. We need a populace in our technological world that is scientifically literate, and the place where this literacy must begin is at the elementary level. It can be done.

5.3

SOLAR ENERGY IN THE ELEMENTARY SCHOOL

Varda Bar

Abstract
An experiment in active learning of solar energy and its uses in an elementary school is described. The aim of the experiment was to influence the attitudes of the pupils by demonstrating to them the possibility of substituting solar energy for fossil fuel.
The change in the pupils' attitudes was expressed in their essays.

Introduction
Teaching this subject in the fifth grade of an elementary school in Israel was motivated by pupils' questions about the ability to continue technological development in a country which does not have fossil fuel resources. These questions reflected uncertainties the pupils had about the possibility of continuing the way of life they were used to.

In order to deal rationally with these uncertainties we decided to present solar energy as an alternative energy source for the many uses of oil. The reasons for preferring solar energy to other possible alternative energy sources were the following:

Solar energy is free from pollution and does not change the heat ecology of the globe.

The physical knowledge needed to begin to investigate solar energy appliances is minimal and it is within the reach of ten year old pupils. The pupils have only to know that the sun is a source of light and heat.

Through their investigations the children can learn about the following physical occurrences: The daily and yearly motion of the sun, heat conduction, heat absorption and the concentration of het by lenses and mirrors. These have also relevance to other subjects of interest: household economy, optics, geography and astronomy.

The subject of solar energy is suitable for active learning: knowledge can be gathered from many sources, pupils can build models and improve them, they can perform observations and experiments, and they can work individually or in a group.

By carrying out this program we were investigating two questions:

A. Will the attitudes of the pupils change from uncertainty or disbelief in technological development to more confident ones?
B. Is this subject suitable for active learning?

The experiment was carried out in three parallel fifth grade classes of an elementary school in Jerusalem containing one hundred and twenty pupils.

Order of Activities
The following activities were performed through the learning units:

1. *The "passive" solar house:* This acitivity consisted of building a model of a house warmed by the sun, that could keep its warmth through the night. During this activity the problem of heat conduction was investigated, and the many uses of good and poor heat conductors were discussed.
2. *Warming water by the sun:* The household water heater, the solar pool and similar appliances were studied. Their models were built; through these activities the pupils learned about the absorption of heat in various materials.
3. *Heat collecting:* The problem of concentrating the heat into a small area to enable its use for industrial purposes was presented. Methods of collecting solar heat by lenses and mirrors were demonstrated. In order to improve these collectors, the daily and yearly motions of the sun were studied.
4. *Electricity manufacturing:* The solar battery was demonstrated as well as other ways to transfer solar energy into electric power. The other alternatives were the solar pool, the wind and falling water power.

Knowledge about other uses of solar energy was gathered also from reading, thus the pupils learned about the solar car and the use of solar energy in space.

Throughout these activities original Israeli inventions were stressed; this made the subject even more relevant for the pupils.

Method of Teaching
The subject was presented by the method of "Learning by doing." The pupils defined a problem that could be solved by using energy: heating the house, moving a car, heating water, manufacturing electricity and so on. They tried to suggest a solution to the problem using solar energy. In some cases a model was built demonstrating this solution. This first solution was not usually good enough, it needed improvements. A new model was built and this process was repeated until some optimal model was found. At this stage the model was compared to real existing equipment: a household water heater, a solar pool, etc. This comparison was done by observing the appliance, by reading about it, or by hearing about it from people of the University who volunteered for this purpose.

This method will be exemplified in the activity of the "passive solar house." The first solution suggested was similar to a greenhouse, suggesting a transparent house. Of course a house cannot be transparent and thus one transparent wall was made in the model. In order to define the direction of this wall observations were made to locate the sun in the sky. Further improvement of the model were constructing an absorbent wall behind the transparent one and modifying this wall in a way that would allow for air circulation in the "house." Similarly the modification of the solar collector (a lens) was moving this collector in order to follow the motion of the sun in the sky.

Before and After Attitudes
As was described in the introduction we decided to carry out this subject because we realized that the pupils lacked confidence. They expressed their doubts in the future development of our country, and even asked if all the civilization as they knew it would stop (cars, electricity, etc.). Those questions were expressed in discussions as well as in essays they wrote. Our main purpose in presenting solar energy was to show that another alternative exists.

Following this purpose we did not make any formal evaluation of achievements. We assumed that performing the activities contributed both to their knowledge and the improvement of the skills. But we were not mainly interested in the amount of knowledge that the pupils acquired nor in the extent of the improvement of their skills. We were, on the other hand, concerned in the possible changes in the attitudes. In order to follow a change in the attitude we asked them to write essays at the end of the course. In those essays the pupils described their views about solar energy and its possible uses.

In contrast to the views that the pupils had before the beginning of the course, at the end of it they expressed more confidence in the future. They wrote that solar energy can substitute other forms of energy in many ways. In the pupils' language: "Solar energy can be used to move everything in the same way it moves today" or "If we could really use the sun's energy, maybe in space, we would not have anything to worry ....".

This pronounced change in attitude showed we had achieved our purpose.

Concluding Remarks
In carrying out this experiment to teach about solar energy in the fifth grade of an elementary school we wanted to find if the performance of the activities would affect the attitudes of the pupils, and if the active learning was a suitable way for teaching this subject.
The change of attitude was demonstrated in the change of views that were expressed by the pupils, before the course and after it. The

views expressed after the course were more optimistic due to the encounter with the uses of solar energy.
The success of the active learning was stressed by the fact the pupils themselves were responsible for the process of learning: they defined the problems, suggested solutions to them, gradually improved those solutions and searched for more knowledge from many available sources. Their motivation in doing so proved that they were really interested in this subject.

SESSION 6: INSTRUCTION UNITS — SECONDARY

6.1 INVITED

AN INTRODUCTION TO THE CONCEPT OF ENERGY FOR 15-YEAR-OLD PUPILS IN FRANCE

By G. Lemeignan and G. Delacote

Introduction

The curriculum that shall be described and which deals basically with the notion of energy, is part (1/3) of a longer curriculum centered on physics and chemistry for 15-year-old French pupils.

Indeed, since 1977, there has been a new physics and chemistry curriculum in France designed and implemented for the French middle school (11-15 year-old pupils). This compulsory curriculum requires 1.5 periods a week (each period lasting 55 minutes) during the four years of the French "college." (There is also another 1.5 period a week devoted to biology and geology). The part devoted to energy is therefore only 1.12th of the total time spent on physics and chemistry notions by any young French pupil; furthermore, it comes only at the end of the fourth year curriculum, trying to build on previous learning experiences of the pupil.

The other two parts of the physics and chemistry curriculum in the last year of middle school are, roughly speaking based on mechanics (force, motion, interaction) and molecular chemistry (notion of molecules, writing of chemical equations, excluding the notion of mole).

A short history

The usual way of reforming the science curriculum in France is to establish, after a short period of experimentation in a very limited number of schools, new programs (or syllabus in American terminology), based, whenever possible, on empirical criticism made by the teachers and to implement them nation-wide at once. The educative system, of course, reacts slowly and it sometimes takes at least 5 years until the program is stabilized. After 10 years, the program is considered more or less obsolete and the time therefore ripe for a new reform.

In the present case, physics and chemistry had not previously been taught in France at this level except for what was called a "technology slot" which was a mixture of the study of mass, weight, and the functioning of simple technological objects like the rail-curtain or the door lock (the simplest one, of course). The idea was good, but the teaching bored a lot of teachers and pupils alike during the 1960's.

This time, in order to decide on the content of the new syllabus, a working party was set up which decided to rely upon the experimental and national work done by a group of scientists and middle school teachers based in one of the thirteen universities in Paris. It is interesting to note that since 1971, when this working party was created, it has evolved into a laboratory, recognizd by the National Research Council of France for research done in science education. This laboratory is unique in France, a country which likes singularities and has also developed a training program for young researchers, similar to the Sesame Program for PhD's in science education developed at the University of Berkeley.

This working group decided to experiment with a certain number of units called "modules." (There were 10 of these modules developed over 6 years.) Among these was one of "Energy."

The aims of the experimentation was to try to work with "objectives in mind," to watch the reactions, motivations,and learning achievements of the pupils (14-15 years olds) as well as the teachers. This is more or less the canonical approach to what Americans usually refer to as a "project."

The end product turned out to be - rather unexpectedly - a student book and a teacher guide which were sold for the first time in 1980 in the free market (10% of total sales).

There were, therefore, two phases in this project. The first was the experiment done with the teachers (over 2 years in duration), the reports written, the conclusions reached. The second phase was the writing of a commercial textbook. It turned out that the second phase was much harder - and of shorter duration! - than the first, but very useful for an in-depth scrutiny of all the ideas which had been launched and tested in the previous experiments.

Furthermore, the knowledge acquired when teaching this energy "module" (approximately 20 hours of teaching) had to be cast into the general non-conventional (at least in France) structure we had adopted for the student's book and the teacher's guide (there was one student book and one teacher guide per college year). Thus, instead of allowing for chapters in sequence - as is usually the caes - the book is based on a certain number of homogeneous parts, roughly grouped under three main headings: Documents, Activities, Encyclopedia. The aim of the documents is to provide starting points for problems arising from everyday life situations, or further readings, etc. The aims of activities are to provide problems to be solved, and research to be carried out, etc. The aim of the encyclopedia is to provide the basic knowledge in a frame which may be used later by adults using encyclopedia at home. This structure was inspired by a reflection of what could be the role printed materials when learning science and also by the basic intention of leaving the teacher free to organize his/her own teaching. The title of the series is eloquent in itself. The books are entitle, "The Free Path Series."

Description of the curriculum

Content

According to what has been said, it is not possible to describe a sequence of teaching to introduce energy. Rather, we may quote some objectives of importance. Indeed, the approach has to be somewhat experimental and be able to facilitate a process whereby the pupil may gain some evidence about the notion of energy by many means, among which are logical reasoning the the verdict of experience. Therefore, we won't stress any further the so-called "objectives of method" but rather focus on knowledge and "know-how" objectives. The following is a list of the main objectives of knowledge.

- to be able to identify the different energy forms and to discriminate betwen stocked energy and transfered energy (heat, work, radiation);
- to be able to analyze and represent an energetic chain by an ad hoc formalism;
- to be able to indentify in a chain, energy output which is not useful (or used = energy losses). This is a prerequisite for the notion of yield;

* to be able to state the energy conservation principle and use it in a chain;
* to be able to identify the high and low temperature sources in a thermal engine, and to modify them in order to vary the efficiency of the machine;
* to be able to identify the high and low temperature sources in a thermal engine, and to modify them in order to vary the efficiency of the machine;
* to be able to quote energy sources and forms of stocked energy;
* to be able, by modifying the working conditions of an energetic chain, to improve the energy output for the same energy input. This introduces the notion of yield;
* to be able, by modifying the flow of energy along a chain in order to vary the output effect or its duration. This introduces the notion of power;
* to be able to approach the notion of energetic cost.

Calculations and measurements have been included in the list of "know-how" objectives. These include:

* the measurement of a quantity of energy by using the electric counter, or by applying the product V (voltage xI (current) xt (time), or by applying water calorimetric measurement, or by weighing a gas container, or by applying M (mass) xG (gravity acceleration) xh (height).
* the "guesstimation" of energy flow of energy (power) and yield values in different situations borrowed from everyday life situations, etc.

Equipment
In order to foster an experimental approach which, at the same time, would not stray too far away from real life situations, we have designed pieces of equipment which may be useful for the pupils to perform experiments.
One of the guidelines when designing these pieces of equipment was to provide in some cases a replica of everyday life energy chains. The following is a list of pieces we propose to the teacher:

* Different kinds of batteries (dry or not) to build yourself;
* A thermal power plant (using a pressure cooker, a simple home-made turbine wheel, a shaft, two pulleys, a belt, a small magnet motor working as a dynamo, and an electric bulb);
* A wind-operated electric power plant (you use the water from the tap falling on the turbine);
* A car operated by solar cells, or by batteries, or by a rotating inertial wheel;
* A solar pump;
* A small home-made refrigerator (operated by a bicycle pump);
* A solar water-heater (the mirror is in aluminized nylon);
* Thermal engines:
    drinking duck
    thermal helix (operated by a candle)
    thermal ship (operated by a candle)
    thermal merry-go-round (operated by burning alcohol)
    thermal tube ship (operated by a candle)
* An experimental flash (which delivers a light flash).

Controls
We have designed a large number of questions and exercises which are as much quantitative as qualitative. Some of these deal with articles from newspapers to be criticized. Others deal with orders of magnitude.

A typical question would be the following:
"During a winter evening, 10 million French families leave on four electric 100W lightbulbs for 5:00 to 11:00 p.m. What is the amount of oil burned in the plants for the purpose?"

Conclusion
The approach which has been described here is rather new for French teachers and their pupils.
This was clearly seen in the in-service training course that we had to provide in our universities. However, it seems to suit the interest of the pupil and the wide range use of the notion of energy in other fields of knowledge other than physics. In fact, it can be applied to chemistry, technology, biology, earth sciences (geography), etc.

For further details, the reader may wish to consult the following books:

Sciences Physiques 3e livre de l'eleve
livre du professeur

Collection Libre Parcours. HACHETTE, Paris 1980

6.2

ENERGY EDUCATION PROJECT IN A DEVELOPING COUNTRY — PHILIPPINES**

By: Dr. Juanita A. Manalo*

Introduction
The Philippines, like any other country, is faced with the problems of lack of fossil fuels, possible environmental damage, and the high cost of developing alternative sources of energy. The Philippine government has thus embarked on an ambitious energy development program to identify and utilize its indigenous energy resources. However, while the government is focusing its resources on indigenous energy production, significantly much less attention is being devoted to the promotion of, within the various sectors of soceity, a greater awareness of energy, an alertness to its most efficient uses, a recognition of its relation to contemporary and future lifestyles, and an understanding of energy conservation. In short, energy education is underutilized as a mode for creating among the citizenry, a greater awareness of, and capability of effectively dealing with, the problems raised as a result of the end of the cheap fossil fuel era.

Cognizant of both the need to educate the Filipino people and the inadequacies of the government to provide all the necessary energy education, Phillipines Women's University volunteered to complement the existing energy education programs of the government with its own energy education proposal. The goal of the project is to develop desirable values and attitudes towards efficient energy utilization and conservation. The proposal was submitted to Asia Foundation in March, 1980, as an answer to the challenge. This was an offshoot of the environmental education seminars being conducted since 1977, where energy was always one of the issues discussed because of its significance. Collaboration was then sought with the Ministries of Education and Energy and the Science Foundation of the Philippines as early as possible for coordination and better implementation of the project, should it be approved.

It was originally conceived to be an information-dissemination project to reach as many science teachers at the shortest time possible as had been done before but was changed to a research-oriented format in the pre-planning session. In the two-day session organized to crystallize the project activities to be undertaken, representatives of the Ministries of Education and Energy, science professors from various universities, and leading energy experts from government and non-governmental centers were invited to share their expertise and experiences in streamlining the project. The result was a research oriented plan utilizing a few pilot schools to test the energy teaching packages to be prepared by a group of teachers within a set period of time. The planners also agreed that the energy topics would be integrated into the non-science courses like Social Sciences, Math, and the Humanities to strengthen the energy concepts taken up in their science subjects. It was also believed that the objective of developing attitudes and values of energy could better be achieved in these non-science courses.

The project was finally launched on October 1, 1980.

Phases of the Project

A. ENERGY EDUCATION SURVEY

After manning the project and organizing the consultative team, the project started with a two-month survey to assess availability of energy education resources; both human and material, in the Philippines. A questionnaire was prepared to elicit information on who were involved in energy education and the nature of their involvement. It also asked the kind and quantity of education materials available in their institutions. Letters were sent to institutions and agencies believed to be interested and involved in energy education. Follow-ups and personal visits were made to agencies and institutions with voluminous materials that required classifying and recording. Results were analyzed and collated. Copies of the directory are now available containing analysis of the survey results, listings of human and material resources, and where they are available in the Philippines.

Results of the survey showed a very limited number of organizations and human resources are involved in energy education. Emphasis of this education is on non-conventional sources of energy, particularly on biogas and solar energy. Integration into the existing curriculum is also negligible. Energy education activities are irregular because of lack of definite programs. The scanty materials available are 95% foreign in origin and the local ones are limited in content and availability for distribution.

B. PLANNING SESSION

For better coordination and evaluation of the project, the planners recommended the limitation of the number of pilot schools who will test the energy teaching packages. The consesus was that only after the materials had been proven successful should they be used in a wider scale by a bigger number of teachers. The project was therefore limited to the teachers of the Philippine Women's University at its various branches situated in the different geographical locations througout the Philippines. Involved in the project now are the secondary and college teachers of the main campus in Taft Avenue; the elementary and secondary teachers at its branches in Quezon City, Mariveles, Bataan in Northern Luzon and at Davao City in Mindanao. To generate greater interest among these teachers, they were involved as early as possible in the planning session. They were given sufficient energy background through formal lectures on the various energy concepts and at the workshops that followed, they identified the entry points in their respective curriculum for energy concept integration. Energy concepts suggested in the US National Science Teachers' Association energy education program were integrated into the Social Sciences, Math, and Humanities subjects at the three levels of education. They also pinpointed the grade levels where best integration could be achieved. Better results were expected with the grade three pupils because of their earlier grades, and first year students of the secondary and tertiary levels. Integration at any higher level would be too late for them. Energy concepts would be integrated in Science and Social Scienes at the elementary level. For the first year secondary students, energy integration will be done in Math, Social Science, Science, and the Practical Arts, while for the first year college students, it will be done in English, Social Sciences, Math, and Science.

Teachers who would write the modules were selected and they divided the work among themselves. Each writer chose the topic she felt she was most competent in.

Each energy teaching package will include guides for the teachers and students and would have the objectives, a brief discussion of the concept, teaching strategies, materials, time allotment and references.

Writing the Modules

To avoid duplicating previously prepared materials, those developed earlier by the Ministry of Education Center for Appropriate Technology, and Science Education Center of the Philippines were obtained for supplementing study. These, together with the curriculum materials brought home from the Staes by Mrs. Leticia Zerda, an Asia Foundation grantee on Energy Education were used as base materials for the preparation of our own. More materials were requested from the United Staes Department of Energy and the National Science Teachers' Association who had pioneered in the subject. Early arrival of these materials enabled teachers working on the project to use them as examples. The materials were truly helpful and we could not have progressed as fast had they not been available. The format and the concepts were adopted but were modified to suit the needs of the local students.

TEACHING MATERIALS DEVELOPED

1. SLIDES — ENERGY: TODAY AND TOMORROW

Slides to develop an energy story were prepared and these, together with the background material, were given to each pilot school for its own use.

2. TEACHING PACKAGES

Teaching packages for each educational level were prepared to include the six major energy concepts we adopted from the Project for an Energy Enriched Curriculum (PEEC). (1) They are:

1. Energy is a Basic Need.
2. Energy Usefulness if Finite.
3. Energy Use Affects Society.
4. Energy and Environment are Interrelated.
5. Energy and Politics are Closely Linked.
6. What is in the Future for Energy?

Each teaching package contains several lessons developed around an energy concept. Each lesson includes teachers' guides, students' activities, background information on the concept, objectives, teaching strategies, materials, time allocation and target audience. Some extra exercises for pupils, Pre and post tests were also included.

Lessons on What is Energy? Energy is All Around; Sources of Energy (Fossil Fuels, Sun, Wind, Water, Food); Energy Conversions and Consumption - were developed to illustrate the first two major energy concepts and are intended for integration into both Science and Social Science courses at all levels of education.

Teaching packages in English and Pilipino on community workers whose jobs are directly affected by energy or are dependent on its continuous supply were prepared for integration into both Science and Social Science courses at all levels of education.

Teaching packages in English and Pilipino on community workers whose jobs are directly affected by energy or are dependent on its continuous supply were prepared for integration in Social Studies in the elementary grade. Lessons on Energy Users and Consumption of the Various Sectors of Society were prepared for integration in the Social Studies and Mathematics courses of both the secondary and tertiary students.

Environmental effects of extraction, production, transportation and utilization of energy resources are included in the science teaching modules for all levels to illustrate interrelationships between energy and environment.

Energy policies of the government are integrated in History and Government courses while the concept of What's the Future for Energy are included in the science modules on future sources of energy.

Reinforcements of these concepts are made in the energy packages intended for use in Mathematics, Practical Arts, and English classes. Reading materials on energy are utilized to improve vocabulary and comprehension in English, and Mathematical skills in Algebra for the secondary and tertiarly levels. Improved energy utilization and conservation practices are envisioned in the lessons prepared for the Practical Arts students in the secondary level.

Orientation Session

Even before the teaching materials were finalized, orientation sessions were conducted in each of the pilot schools before opening of classes to familiarize the teachers on their use. At each session, an overview of the Energy Education Project and slide presentation of Energy: Today and Tomorrow were conducted. Lectures on Nature of Energy, Energy Resources, Environmental Impacts and the government's energy policies were given to the teachers to provide sufficient background on the energy concepts. Then, a workshop on the evaluation, utilization and adoption of the teaching packages followed. Teachers acquainted themselves with the various lessons available, screened them and decided which of these materials they would want to use in their own classes. At the end of the workshop, each teacher submitted a report on:

1. lessons they want to integrate and why
2. where they would integrate such and when
3. changes in the materials they want to make, if any, to suit the local needs of their students.

These written reports served as their commitment and thus facilitated monitoring of the project.
Although all teachers in the pilot schools were encouraged to use the ideas or the lessons in their own classes, the project was limited only to teachers of grade three pupils and the first year students at the secondary and tertiarly levels of these pilot schools. Findings obtained by the other volunteer teachers are not included in the results of the project.

Evaluation

Every phase of the project is evaluated. To evaluate effectivity of the teaching materials, results of the pre-survey on the attitudes of the participaing students will be compared with the results of the post survey to be conducted at the end of the school-year. Changes in the attitudes of the participating students will also be compared with a control group whenever possible. Some classes are so small that all students will have to participate in the project. To determine an increase in energy information, pre and post tests for every concept will be given to the students. Any difference will be attributed to the effect of the teaching activity.

Implementation and revision

The teaching materials are presently being tried in the various pilot schools. Teachers and students are being monitored to evaluate the results of the project. Based on the teachers' comments, and results of the evaluation, these modules will be revised and improved. Once revised, they will be tried on a regional scale where more teachers in these four regions will be involved.

Future of the project

Orientation seminars on the utilization of the modules will again be conducted to involve the private and public teachers at all levels of education in these regions. Evaluation will be continued and if successful, more and more seminars will be conducted to spread the gospel of ENERGY EDUCATION. We therefore hope that these materials will help the teachers achieve the goal of developing students with changed attitudes about energy.

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6.3

A SHORT COURSE IN ENERGY

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Abstract
This course was developed for use in grades 7-12 by teachers in many subject areas. Information was gathered from companies in the energy field, books, magazines, the local electric company, publications of universities, the U.S. Department of Energy, and The Texas Governor's Office of Energy Resources. The course has been used to make students aware of energy resources, their uses, impact on the environment and economy, and conservation. The result has been an increased awareness in the community of the complexities of an energy-dependent society.

Text
This one-week mini-course was developed to introduce students to many facets of the study of energy. A lesson plan was provided to detail the work for each day. A study guide was given which describes the program, its educational objectives, background material for discussions, and answers for students worksheets. The packet given to each teacher also contains worksheets to be reproduced for each student and overhead transparencies. Wall charts and maps of energy resources are obtained from the science department chairman.

On the first day, energy is defined, and units used to measure types of energy are presented. A chart showing types of energy and materials produced from coal, petroleum and natural gas is used to answer questions on the first worksheet. A second sheet shows conversions of one type of energy to another. Maps are used to show locations of energy resources. (In this program a world map and a map of Texas are used.) Alternate sources of energy (solar, tidal, geothermal, nuclear, etc.) to conventional sources are defined and discussed.

The second day's activities are centered on technology and ecology. Since Texas is a center of the petrochemical industry, the high points of petrochemistry are given. There is a wall chart showing scientists and their contributions, which is used for discussion. The question put is whether the use of petrochemicals is of lesser, equal or greater value than the use of petroleum products for energy. Students are given a list of products to take home and discuss with their parents to see which products were available when their parents and grandparents were teenagers. Students explore uses of energy resources that result in the least damage to the environment. There are books, magazines, pamphlets, etc., available in the department for reference. Good discussions, not to say arguments, have been generated at this point.

On day three, students return sheets they took home, and the class discusses results of family discussions on petrochemical products that were not available just a few years ago. Another "family" assignment is given: to name the rooms of their homes and list all energy-using devices in each room, and, if possible, how much energy each uses. Also, they are asked to check which of these appliances their parents had 25 years ago and which their grandparents had 50 years ago. Several overhead transparencies are used which show energy resources around the world, and the proportion of each that is used by the United States. This leads to a discussion of why we should conserve energy.

The returned lists of appliances are used on day four to stimulte questioning about which of them are luxuries, conveniences or necessities and how families can conserve energy. Overhead transparencies showing proportions of U.S. energy used for transportation, industry, agriculture, commerce, residences, etc., are used to help students see other areas where conservation can be practiced. Worksheets are given out to be used in teaching students how to read their electric meters. They take these home and record the reading on their own meters. They are asked to note the last reading on their electric bill to calculate cost per kilowatt hour. They can also determine how much power they have used since the meter was last read and to make practicable plans for reducing the amount they use. Overhead transparencies are again used to compare the advantage and disadvantages of several energy sources (petroleum, natural gas, nuclear, coal, solar, hydroelectric, tidal, geothermal, wind and synthetic fuels).

Day five begins with a teacher-led discussion of the causes of the energy crisis. This leads into a discussion of future energy sources, conservation of energy and protecting the environment, and the economy. This means maintaining a rather delicate balance and demands critical thinking from the students (and teachers), a bonus to the program. The results of the meter-reading activity are put on the board. These are compared and concrete ideas for conserving electrical energy are written on the board.

A summary of the important things learned and plans for conservation are put on the board. A list of projects for the near future may be added, particularly ones that involve parents and/or the community. The more people are made energy-conscious, the better. If time permits, students are encouraged to work in groups to develop their own national energy program.

This mini-course is updated annually. This year The National Geographic Society generously gave its permission to use materials from "A Special Report in the Public Interest: Energy," a special edition in February, 1981. This is enormously helpful in keeping up with changing figures, and it is necessary to keep the material current.

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6.4

LOW-COST TEACHING OF ENERGY CONVERSION

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There is considerable discussion of energy conservation, both in academic circles and in the community at large. The terms used by politicians and planners often reveal a fundamental lack of understanding of the science and technology of energy. In particular energy is not consumed, it is converted from one form to others. Also, energy is of no value if it is merely conserved, it is valuable only when it does useful work as it is converted.

Our task as educators is to teach the citizens and leaders of the future to use energy wisely. If pupils are to be sensitized to these issues they must receive explicit teaching of energy conversion. The ability to recite, "energy is the capacity to do work," and, ignoring the circularity of the argument, "work is done when energy is converted from one form to another," is of little value. Pupils should preferably experience for themselves, or at least see and discuss demonstrations of energy conversions.

The topic often occurs in physics and general science curricula in the lower secondary age range, for pupils 12 to 16 years old. In Britain energy conversion has been taught using a circus of practical work. The Nuffield Secondary Science texts' provide a typical example of this approach. The Nuffield energy conversion kit developed for teaching this topic currently sells at U.S. $680. This price places it out of reach of many schools.

Many items needed in teaching energy conversion can be improvised. This is cheap, and the equipment is available more quickly than it is from regular laboratory suppliers. It can be adapted, and repaired if broken, in a way that factory-made items cannot.

There are two main methods of approaching improvisation. One is to put an existing object to a new use. The kinetic energy of a spinning wheel of an inverted bicycle can be turned to heat by cautiously putting a finger, wrapped in paper, on the tyre. A hinged door, which moves more easily when pushed near the moving edge, demonstrates lever action. The handle of a drinking mug can act as a pulley. If the string is marked in decimetres the velocity ratio of the system is clearly seen. Multiple pulleys can be demonstrated by passing the string several times through and between the handles of two mugs.

The second method of improvising consists of making apparatus from available materials such as jars, string, wire, tins, coconut shells or bamboo. The preferred approach is to consider the job the equipment is to do, then how it may be done with the materials on hand. Attempts to copy factory-made apparatus are usually unsuccessful. The Nuffield kit previously mentioned contains a water turbine. This turns a pulley when water from a tap passes through it. Copying this involves making joints which are watertight, but which are free enough to let the turbine shaft rotate. This is virtually impossible without the services of a workshop and machine tools. A model with blades cut from a scrap tin and stuck into a carrot or similar hard fruit or vegetable, rotating on two nails, demonstrates the same energy conversion. The nail is wound up as kinetic energy is converted to potential energy. When the flow of water stops the nail falls, turning the turbine and reconverting the potential energy to kinetic energy. This shows that it is possible to analyse the results of an experiment at various levels of sophistication. Thus, a piece of improvised equipment can be used with pupils of different ages.

There is an extensive literature on improvised equipment, ranging from items produced by skilled technicians,[2,3] to items which science teachers can make themselves.[4,5] Some instruction in improvisation is desirable in all courses taken by students training to become science teachers.

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6.5

Y.E.S. - STUDENTS EDUCATE YOUTH

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Abstract:
Y.E.S. - Students Educate Youth is a program designed to stimulate interest in and increase knowledge about one's environment. The program begins as one that is scholastic academic in nature, using the scientific method to help junior high school students explore their environment, and ends as one that is concerned with the social development of the students, allowing them to use their knowledge, skills, and talents to develop programs designed for elementary school children. The section of the program described is that which deals with energy and the Energy Fair the students present at the end of their studies.

Text

Y.E.S. - Students Educate Youth is a program designed to stimulate interest in and increase knowledge about one's environment. Students involved in Y.E.S. use the scientific method to explore the biotic and abiotic environments of their communities. They share their knowledge with elementary school children through a series of specially designed activities.

The goals of Y.E.S. are to help individuals acquire:

1. a clear understanding of the nature of scientific inquiry. Science is an open ended intellectual activity. What is presently known or believed is subject to change.

2. an understanding of the limits of science and the scientific methods. Some problems of great importance can not be dealt with through science.

3. an understanding of the great diversity of life and the interrelations among the living organisms and the living organisms and the abiotic environment.

4. an appreciation of the beauty, drama, and tragedy of nature.

5. an understanding of man's own place in nature as a living organism who interacts with all organisms in the biological systems of earth.

6. a clear understanding that man is an inseparable part of a system, consisting of man, culture, and the biophysical environment and that man has the ability to alter the interrelationships of this system.

7. a broad understanding of the biophysical environment, both natural and man-made and its role in contemporary society.

8. a fundamental understanding of the biophysical environmental problems confronting man, how to help solve these problems, and the responsibility of citizens and government to work toward their solution.

9. attitudes of concern for the quality of the biophysical environment which will motivate citizens to participate in biophysical environmental problem solving.

In helping students to reach these goals Y.E.S. will help to build citizens who are:

1. interested in their environment and its relationship to society

2. sensitive to the environment - both its natural and man-made aspects

3. sensitive to the dimension of quality of their environment and able to recognize environmental problems

4. inclined to participate in coping with environmental problems

5. willing to share their knowledge and skills to help educate others

As related to energy education the first emphasis of Y.E.S. deals with those parts of the scientific method that will give students insight into the work of the scientists presently concerned with the utilization and conservation of our present energy resources and with the search for feasible future sources. From this emphasis arises the scientific spirit of inquiry.

The second emphasis of Y.E.S. deals with that part of the scientific method which will make students aware of the role they shall assume as leaders of tomorrow.

The second emphasis is not a distinct section removed from the first, rather the sharing of acquired skills and knowledge is an integral part of the program just as it is an integral part of good citizenship.
Searching into the nature of things, experimenting, analyzing data, generalizing, predicting, and sharing are the spirit of Y.E.S. while the subject matter we are concerned with in this case is energy.

Three specific sections of Y.E.S. are concerned with energy. Prior to studying these sections the student will have attained a frame of reference by studying ecosystems, the basic functional units of nature, and the abiotic factors that affect ecosystems. Having investigated the structure of an ecosystem the student will investigate energy flow and nature's metabolism.

The energy that moves through nature's ecosystem is of prime importance to man. Headlines announcing fuel shortages, increasing fuel prices, and plans to decrease energy consumption have increased our awareness. Specially designed lessons will allow the student to add to his knowledge of energy flow through the ecosystem as he studies how the U.S. is currently obtaining its energy and evaluates future energy sources. The classroom lessons will end with a series of presentations and activities designed to teach the student things that he and his family can do to help conserve energy.

The acquisition of knowledge provides the student with only a partial education. It is his responsibility as a productive member of society to share his knowledge with others. The student will fulfill this responsibility by presenting an Energy Fair for third grade children. At this point the program moves from one which is scholastic academic in nature to one that is concerned with the social development of the students.

The Energy Fair consists of a short introductory movie, an energy carnival with booths designed to teach children an energy related concept through the playing of a game, and a series of arts and crafts activities in which the children will construct mobiles to show energy flow, collages to show methods of conserving energy, draftometers to check the tightness of doors and windows, lightswitch covers, and pencil holders decorated with energy saving ideas. Each elementary school spends one and one half hours at the fair. Each elementary student is guided through the activities by a junior high school student. The junior high school student follows a very specific plan that allows him to give the child that he is working with an opportunity to complete a maximum number of activities. The plan allows the junior high school student to adjust each activity to meet the needs of the elementary schools tudent with whom he is working. Each elementary school student will leave with a book of energy games and puzzles the junior high school students have written; a chest covered with badges and a bag of penny candy, his prizes from the carnival; his arts and crafts activities; and a hat made from recycled paper. But, more important, he will leave with a self-image that has been enhanced through the special attention he received from an older child and the accomplishments that he attained during the day.

To begin to plan the Energy Fair each student is given the task of working with a small group of his peers to design a carnival type of booth that will teach a third grade child, through active participation, about some aspect of energy, energy sources, or energy conservation. The students in the group must first come to a consensus about what aspect of their energy education they consider most important and wish to teach others. In this phase it is not unusual for one student to emerge as an academic leader. This student is usually one who is known to have done well during the unit and thus faith is put in his opinion of what merits teaching. Once the topic is agreed upon the method of presentation must be determined. In this phase the student who assumes leadership is the member of the group who is the most cretive, who can think of the most novel approach.

As construction of the booth begins two other types of students will usually emerge to guide the group- those with the most artistic ability and those who can work well with their hands to turn a paper and pencil idea into reality. Thus, careful selection by the teacher can result in the formation of a group in which each student will have a turn as both leader and follower, a group in which each student will reach his full potential.

Materials and time must be provided so that the students can complete their booths. Two liter bottles may be converted to energy wasters that can be captured in a ring toss game, balloons can become lightbulbs carelessly left on to be shut off by a well thrown dart, or a golf ball that falls through the right hole may strike a switch that will turn out a light.

While the students work with their groups in school they are given tasks that can be completed at home without the aid of their friends. Badges must be made that can be used as prizes at some of the booths. A sheet of directions, and the necessary paper, stars, and ribbons must be distributed in such a way that each student can take home and return a set of prizes. In addition to completing his share of the badges each student must create a page for the activity book. Looking through children's coloring books and games books will help the students to realize what the third grader is capable of doing. After the student has created his page and had it checked the page can be transferred to a master and run off. When all of the pages are completed an assembly line will quickly put the hook together.

As the day of the Energy Fair approaches a pamphlet must be prepared that will let each junior high school student know exactly what his responsibilites are, the total plan of the day, and where he should be at any given time. The pamphlet must provide a list of activities that must be completed to set the fair up and who is responsible for each, pictures that show the students how to set up the wall decorations and where to place the arts and crafts materials, a list that assigns each junior high school student to a specific group, and a schedule that places each group in a specific location for each period of time. A floor plan must be provided so that there is no question about the location of a booth or a piece of apparatus. A time line for each school that will attend, a description of each booth and how it should be played, as well as directions for each arts and crafts activity must be included. Each student's clean-up responsibility must be clearly stated. The pamphlet should be reviewed with the students and methods of making the day most beneficial for the elementary school children should be discussed.

The actual setting up of the fair should be completed the afternoon before the fair. This will allow some time for adjustments the morning of the fair.

As the elementary school children arrive they can be paired with junior high school students who can help them ot make an energy savers thinking cap and guide them to the movie theater. The introductory movie will help to give the junior high school student a basis for the material he will be presenting and discussing with the child.

After the movie the junior high school students move to their assigned locations in the carnival or the arts and crafts area and work with their children. They may move freely from one acitivity to the next as long as they remain at either the carnival or the arts and crafts area. How long is spent at each booth in the carnival or each arts and crafts activity depends on the abilities and interests of the elementary school child. When the signal is given, halfway through the alloted time, the children at the carnival move with their junior high school guide to the arts and crafts activities and those in the arts and crafts area move to the carnival. This insures that an equal amount of time is spent at each activity. While there never seems to be enought time at the carnival added activities such as a mural to draw on or microscopes to look through are helpful to those who finish the crafts activities early.

A break of fifteen minutes between the departure of one school and the arrival of the next will allow for the booths to be restored to order and the arts and crafts materials to be replenished. Again specific tasks must be assigned to insure an orderly transition.

As the final group of the day is getting their coats and bags of completed crafts activities to take home the junior high school guides may offer them the decorations that were used through the day. In this way the children take back to their classrooms and homes large visual reminders of their experiences.

Through Y.E.S. elementary school students can learn about energy and how it can be conserved while junior high school students become productive citizens through not only acquiring a storehouse of knowledge that will serve them in the future but also by sharing their knowledge with others in an effort to build a better environment.

Y.E.S. was developed by the author. Further information may be obtained by contacting her at 9 Stevens Road, Lexington, Massachusetts 02173.

6.6

"APPROPRIATE ENERGY EDUCATION AND TECHNOLOGY"

Joe W. Priest, Science Department, UCISD, 1000 North Getty,
Uvalde, Texas, 78801, USA.

As a teacher in the sunny southern community of Uvalde, Texas, I recently initiated an Energy Education Project for seventh grade students. I sought a very broad approach to the problem in order to involve as many individuals as possible, hoping, in the end, to present appropriate education and technology to this low-income community.

In order to make students aware of related fields of technology, I presented them job descriptions of Design Engineer, Construction Engineer, Experiment Analyst, as well as "Data Searcher," Publicist, and Photographer. After surveying contemporary alternative energy sources, solar heat was chosen as most appropriate for our project. Together we designed and constructed a passive solar space heater, installed it in our classroom window, and are in the process of analyzing the solar contribution. We submitted stories of the Energy Project in school newsletters, local newspapers, and the Xerox Educational Publications Company. This process effectively involved students from all levels of academic achievement.

As a community outreach, future activities planned include seminars on solar heating and cooling theories, construction techniques, and evaluation methods.

Having accomplished the original goal of the project, the students were issued personally designed "Solar/Renewable Energy" T-shirts, thus spreading the good news well into the warm South Texas Spring.

SESSION 7: ENERGY EDUCATION IN SECONDARY SCIENCE

7.1

OUR COSMIC ENERGY BUDGET

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The history of the Universe can be told as the history of cosmic energy dissipation. Big Bang explains the origins of nuclear energy. Life explains the origins of chemical fuels. Human society learns digging deeper and deeper for free energy in the cosmic past, to drive its machines, its civilization. By presenting this cosmic perspective in school the coming generations can be educated to understand the energy options and to face the technological and moral challenges of future.

In school energy is taught to be able to transform into various forms, but its overall amount is strictly conserved. "But then why do we import energy carriers? The energy does not disappear!" — is asked by clever pupils. Power stations are located on sea shores or river sides, elsewhere giant cooling towers are built to dissipate heat. "Why do we waste energy obtained from expensive fuel?" — is another question of openminded young brains. If the teacher is interested in making steps beyond the pragmatic recipes of everyday life, if she or he intends to illuminate our energy perspectives and energy options, it is worth offering a bird eye's view of the whole problem.

The universe is a closed system of innumerable particles, it has inexhaustibley many degrees of freedom. In nature and in human economy any concentrated energy dissipates sooner or later to the many degrees of freedom available in our world. As it is expressed by scientists: *energy is conserved*/First Law/ but *disorder increases* spontaneously/Second Law/. When one is interested in creating order, in concentrating energy/to produce locomation/, one has to pay for this unnatural course of events: elsewhere more energy must be dissipated to other degrees of freedom of matter. Only this way can society reach its technical goals without violating the laws of nature.

This Second Law of thermodynamics was discovered in the past century, when the Industrial Revolution became interested in constructing steam-engines. But this understanding produced a lot of headache elsewhere. In the closed universe total disorder/maximum entropy, a heat death predicted by Clausius/should be the natural result of events. "How come, that in our world one still finds heat and cold, light and darkness, decay and birth?" These questions tormented among others Ludwig von Boltzmann, contributing to his suicide on a coastal resort just in the summer 75 years ago.

The explanation was understood only in our century. The equations of motions for matter do not have static solution: the Moon cannot stand still in the sky. A stone cannot float in the air, it has to fall down to earth, or — if possessing kinetic energy enough — it has to fly away. This theoretical conclusion of Alexei Friedman/USSR, in the twenties/has been confirmed by Hawking and Penrose/UK, in the sixties/in full rigour. It has been observed by Hubble/USA, in the thirties/, that the set of galaxies runs apart indeed. By extrapolating back into the past, one reaches a time of infinitely high density about 15 billion years ago.

If the particles were compressed tremendously, they had to produce the most stable medium heavy nuclei/mets like iron/. On the other hand the present actual universe is dominated by the lightest elements. The only explanation can be — argued Gamow — that the early universe was hot. It cooled down by adiabatic expansion, like hot air above sunny land raises up and cools down, to produce hails in August.

The leftover of this early hot universe was discovered by the radio engineers of the Bell Laboratory, when in the sixties they were scanning the sky for quiet radio bands. From the present radiation temperature -270° C= 3 K it is possible to reconstruct the course of events. The Planck spectrum of radiation indicates that the early hot universe was in state of complete disorder. *In the very first second* of its existence the temperature was above 10^{10} centigrades. In such a heat no composite nuclei existed, free protons and free neutrons transformed into each other in violent collisions.

After the first second the thermal motion dropped below 1 MeV. The collisions were not able to produce new neutrons any longer. The existing neutrons decayed gradually. But before they all had time to decay, in the first three minutes the protons captured neutrons, by fusion they built up the first composite nuclei, like deuterium, helium, lithium. But the fast drop of temperature and the spontaneous decay of the remaining neutrons terminated this fusion chain before reaching equilibrium. From the primordial particles only the first few elements of the periodic table were produced. The mutual electric repulsion prevented any futher nuclear buildup in the cooling gas: the matter was trapped in the Coulomb potential valleys of light nuclei.

Millions of years passed by, until the temperature dropped below thousand degrees. The protons calmed down, they captured electrons and formed hydrogen atoms. The universe was filled by luke-warm hydrogen gas(a good first approximation even for today), contaminated by helium and by tiny traces of other light atoms(deuterium and lithium did not make more than 10^{-5} percent). The cooling gas became unstable against gravitational contraction. It split into dense hydrogen clouds, these fragmented to galaxies, the galaxies to stars. The falling stellar layers liberated gravitational energy, which heated the gas sphere to glowing and to shining. The darkness of space was illuminated once again by starlight.

The gravitational work increased the central temperature above million degrees. The proton collisions became more and more violent. Occasionally quantum tunnelling helped a proton through the repulsive potential wall of the other one. In even more rare lucky cases the transient conglomerate suffered radioactive decay.

By emitting a positive electron, heavy hydrogen was formed: deuterium. Its nuclear binding energy was radiated off, feeding and prolonging the shining of the star. The deuterium is, however, not long-lived at several million degrees: it merges into helium.

$$d + d \longrightarrow {}^{4}He.$$

In details: ${}^{2}H + {}^{2}H \longrightarrow {}^{3}He + {}^{1}H$, ${}^{3}He + {}^{3}He \longrightarrow {}^{4}He + {}^{1}H + {}^{1}H$. The helium nucleus possesses a closed shell, it is stable even at this temperature. In most stars of our night sky hydrogen. $\longrightarrow$ helium build-up feeds the central power station, it supplies the stellar radiation through billions of years. The flow of nuclear matter towards the equilibrium state is retarded by Coulomb barriers. Even now ¾ of the universe is made of promordial hydrogen, ¼ of helium.

When the hydrogen supply of the central core gets exhausted, the thermal fusion stops. The radiation loss of the star can be covered again only by gravitational work. The new contraction heats the star up to 100 million degrees. At this high temperature even triple collisions become frequent. The impact speeds are enough to penetrate potential barriers around nuclei with increasing electric charge. So the nuclear build-up goes further:

$$3\,He \longrightarrow C, \qquad He + C \longrightarrow O.$$

Oxygen — 16 is again a closed shell structure, at which the fusion chain stops. Red giant stars (like the Antares and Acturus on the evening sky of the harvest moon) produce carbon and oxygen of helium. The stellar wind, blowing out from the stellar surface, contaminates the space by these life-essential elements up to a part per thousand.

Where have the other elements been made, e.g. the metals? A simple answer is: nowhere. The stars are not yet old enough to develop such a high temperature, where collision speeds make the penetration of the increased potential walls encircling oxygen nuclei possible. The amount of metals is negligible even in third approximation.

A sun-sized star lives in hydrogen-burning state longer than the present age of our Galaxy. But a considerable overweight results faster aging: a star of ten solar masses radiates more lavishly, it exhausts its hydrogen and helium supply within one billion years. In the critical period of diminishing nuclear fuel the star shrinks with uncontrolled speed, the work performed by gravitational pull heats it up to billions of degrees, all the channels open up for nuclear reactions, so an equilibrium population is realized along the periodic table of chemical elements. The most abundant elements are iron and the neighbouring metals. But at such a high temperature not only the states of minimum energy are populated but in a smaller amount also the states with higher energy content are present: the light nuclei and the very heavy radioactive ones/like uranium and throium/as well. By reaching the end station of nuclear evolution the death of the giant star arrives with complete collapse. The liberated heat gives rise to a shock wave, which strips the outer stellar layers off. The fast spreading gas envelope raises the brilliance of the dying star for a few weeks: astronomers register it as supernova explosion. The ejected metal-rich gas cools down, it surges the neighbouring interstellar gas and dust. New density concentrations are formed, bearing a second generation of stars. These are contaminated not only by carbon and oxygen, but - to 0.01 percent by metals (fourth approximation). Our Sun was born in this way less than five billion years ago.

If the star-bearing cloud was whirling, its angular momentum prevented its shrinking to a single star. The outer fragments took over the angular momentum by their orbiting and spinning motion. Only the birth of planets enabled the central mass to become a star.

The most common elements in the planet-forming material were hydrogen, helium, oxygen, carbon, with traces of some other elements. Consequently the most common compounds of the gas and dust were H_2, noble gases, H_2O, CH_4, CO_2 and metal oxydes in decreasing order. This composition can be found in the outer planets of the Solar System. In the luke-warm inner region however the hydrogen and noble gas never condensed, they were blown out by the solar radiation and solar wind. The planetary cores were built of metal compounds, surrounded by atmospheres of water, methane and carbon dioxide.

The fast-decaying radioactive elements — originated in the supernova — melted the body of the planet, to be called Earth, which produced a chemical separation by weight. Within half a billion years most radioactive isotopes decayed, leaving back only the long-lived uranium and thorium. Slowly rigid crust was formed, ocean of H_2O was precipitated and a carbonrich atmosphere of CH_4, CO_2 was left. Hydrogen escaped gradually, so one would expect oxydized planets (H_2O, CO_2, Fe_2O_3 etc). This equilibrium composition can be observed on the present Venus and Mars. But the fate of our own planet turned out to be very different.

Earth is not a closed system. The star called Sun was made mostly of the primordial hydrogen. This solar material leaked slowly through potential tunnels towards energy-deeper equilibrium, the energy set free fed the sunshine. The hot rays of Sun hit the molecules of Earth. Chemical reaction formed a selection of new compounds.

$H_2C{=}O$ is a polar compound, soluble in water. With it rains washed carbon into the ocean. The double bonds meant reactivity. The formaldehyde was polimerized to sugar.

$$6H_2C{=}O \longrightarrow C_6H_{12}O_6 \text{ (glucose)}.$$

The high energy bonds of sugar conserved a fraction of energy from the absorbed sunlight, so seawater became a nourishing soup, out of chemical equilibrium, due to the flood of sunshine. In this soup creatures were formed in a suprisingly short time (within a quarter of a billion years), they fed on this broth and spread fast. Soon they ate up all the nourishing compounds from the ocean. In the coming poor years of starvation, some organisms invented photosynthesis: by their extended molecular aerials they collected even the tiny energy quanta and so they produced sugar and protein for themselves. These biological heat engines worked by making use of the temperature difference between the 6000 K hot sunlight and the 300 K cool atmosphere, they extracted red quanta from the sunshine and so made the Earth green. Carbon was separated from carbon dioxide, hydrogen from water, the collected free energy stored in the bonds of carbohydrogen/oil/and carbohydrate/sugar, starch, cellulose/molecules for the hard days. Oxygen was left over, which changed the chemical character of the atmosphere.

Combustible organic compounds in the sea, in the grass, in the woods and oxygen-rich atmosphere above them built up a chemical tension, unprecedented in the Solar System. Some pushful creatures learned to exploit this chemical tension: by feeding on organic fuel, by combusting it at an accelerated rate in the oxygen -enhanced atmosphere they were able to realize a more intensive way of living: locomotion, predatory behaviour, fast evolution. The world of animals succeeded in constructing more and more efficient regulatory and replicative systems. In less than a billion years a socialized animal called man emerged. By his social structure man performed the exploitation of the natural sources of free energy with an unprecedented intensity. Man invented fire, cooking, heating, industry, steam-engine, inner combustion engine.

Before the industrial revolution man made use of wood to get free energy. This meant that tiny fractions of the actual power of the permanently working thermonuclear reactor inside the Sun was captured; the Solar energy was transformed to chemical fuel by natural photosynthesis.

The industrial revolution has increased the public demand in free energy to drive the machines. Man has started mining, coal, oil, gas. Mankind consumes fossil fuels, collectd by the green biosphere from solar radiation through millions of years. The worldwide industrial revolution empties terrestrial reservoirs of the chemically stored solar energy within century. The end of the fossile fuel supply has come within sight.

Taking the present energy hunger into account, our society has to face a dilemma: Either to go back to the pre-industrial stage, using the renewable energy sources of woods, winds, waves , rivers, accepting the fact, that this soft energy enables only a rural way of living for much less people than live today. Or to insist on the comfortable centralized distrubition of energy through a network of wires and pipe lines, which is a condition for the urban life style, consequently to open deeper reservoirs of hard energy. A possible option is offered by energy of the ancient supernova trapped in the nuclei of unranium and thorium. These many billion degrees hot sparks offer us highly concentrated free energy, but the seals are luckily - hard to break. The whole undertaking needs more initiatives and the game is getting more dangerous: any run-away war game may lead to global catastrophe. The pros and cons of the energy dilemma are burning in the mind of our generation. Anyway, man has learned to know how to build fission reactors and these offer a way to survive the coming poor decades at the turn of second millenium.

The coming generations have to survive by nuclear power stations, they have to live together with radioactive waste, in the shade of nuclear weapons. Is there any clear sky, are there any rich decades within sight for them? The controlled fusion of light nuclei is a great promise for the next century. The light elements, like the very heavy ones, are out of nuclear equilibrium, high above the level of the iron sea. Hydrogene and its neighbours have preserved the very high temperature of the early hot universe, due to the slowness of stellar evolution compared to the speed of biological and social progress. Fortunately, we live in young universe! The man-made thermonuclear installations are about using deuterium and lithium as fuels, left over from the first three minutes. Most learned people are inclined to think about the next century, as the age of proliferation of thermonuclear technology, but they know, that this must be an age of social responsibility as well. It is up to our children and grandchildren, to realize this dream. It is up to us, to educate them to be inventive and responsible enough for this heritage.

School is a social invention to prepare new generations for social adaptation. In slowly rolling times the school might be satisfied with cultural reproduction: with transfer of social experiences from generation to generation. In a time of acelerated progress this policy is inefficient and may produce harmful conflicts.

Let ups consider physics teaching. The central concept of traditional school physics was force. The static concept of force had been introduced by spring, which was completely satisfactory to visualize static equilibrium, which might be helpful in the age of handicraft, but it has become of less use to understand the dynamical behavior. It is even a greater problem, that this force concept is of no use in the sciences, e.g. for the description of the motion of heat, of light, of fields. The chemical force (valence) and the "vis vitalis" (of biology) are concepts, completely different. So traditional school physcis appears to be an outdated "1" art pour l'art" of school masters in the eyes of young people, it has become rather irrelevant for the present and future of society.

According to a recent evaluation of the European Physical Society, in the past decade most European countries introduced new physcis curricula to cure this disease. In our country a main characteristic of the new physics curriculum is the energy takes over the central role from force. Energy is a convertible currency in science, technology and economy. In the junior high school energy gets an early operative definition: energy is what one can warm water with. This introduction is not only understandable, practical, and quantitative, but it leads us beyond the classical pair of kinetic and potential energy. It includes inner energy, chemical and nuclear energy and the energy of light as well, with have got central role in our economic thinking. In the senior high school mechanics is based on conservation theorems. In electrodynamcis the study of currents and fields is motivated by pointing to the versatile handling of energy and information. Thermodynamics concentrates on the statistical aspect of the Second Law: how the dissipation of energy determines the direction of events. Atomic and nuclear physics deals with ground state, excited state, binding energy, band structure. On this way pupils get oriented not only in physics books but also among the open problems of the present world. As conclusion our curriculum offers a cosmic view of the energy budget showing place of Earth and mankind in the universe. The flow energy is a useful guide line to trace the follow of events, as it was sketched in the first half of this talk. On this way the youthful romanticism is directed to astronomy, the intellectual challenge of Big Bang is connected with the fate of our terrestrial ecosphere. So to the end of our very earthy problems may appear not as heavy burdens but as exciting challenges. It is easy to fill these chapters with hard content and scientific activity, leading to the conclusion, that science is relevant for people, even the best hope for them.

Our ecoshpere is not in the state of thermal equilibrium. The curious phenomenon called life created chemical tension between the organics matter and oxydizing atmosphere. Grazing animals and fire making men exploit this chance since millions of years.

Our whole univese is not in static equilibrium either. This is a deep understanding of the 20th century. The speed of the expension and the slowness of the stellar evolution drove matter out of its primordial equilibrium, resulting in a thermodynamical tension between "hot" nuclear fuel and "cool" environment. It is now our share to make use of it.

Our society has now got out of equilibrium. The fast progress of science and technology on the one hand, the slowness of the adaptation of human moral and public understanding on the other hand has increased the social tension, which produces discharges from time to time. In our days tension is increasing to a dangerous level. The old saying was never so true as it is now: Future is a race between catastrophy and education. We, science teachers have the moral obligation to face and answer this challenge. Surely science is the best tool man invented to find our way in the unknown and to solve new problems.

7.2

The Role of the Second Law of Thermodynamics in Energy Education

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Abstract
At present there is a conflict between the law of conservation of energy in the classroom and the admonition "to conserve energy" in the media. A resolution of this conflict can be provided by the understanding of the difference between the internal energy of a system and its free energy.

The usefulness of the concept of free energy can be demonstrated after entropy has been introduced. Simple examples of how this can be done will be presented. Attention will also be given to the importance of the concentration of fuel reserves in determining their usefulness as a resource.

Introduction
"Energy Education" is a strange term. The reasons for its existence must have something to do with limited oil reserves, nuclear power plants, acid rain, etc. Yet there are other topics that have scientific technical, economic and social implications, which have not been teamed up with "education." Has anybody heard of "Pollution Education?" "Energy Education" being a new and broad term may mean different things to different people in different contexts.

In this lecture I wish to address one aspect of "Energy Education" in the context of science education during a time interval spanning from, say, the eighth school year through the twelfth school year. I shall spend most of the time on what might be done at the beginning of this period, because that is where it can have a larger impact. Having come to find syllabi, i.e., listing of topics, to be a most unsatisfactory way of describing an education process, I shall try to express my thoughts in a more descriptive way to enable you to imagine what may actually go on in a classroom.

A Philosophy of Science Education
To begin with, let me outline the philosophy of science education that is behind the approach and content which will follow.

(a) We increase the ability of students to focus on the subject matter if we first describe facts and express ideas in words with which they are familiar. The need for a new term should be established before it is introduced. This way the term will have an operational meaning and will be better integrated with the students' natural vocabulary. As simple and obvious as this premise may sound, teachers, textbooks writers and publishers widely believe that teaching science consists first of all to memorizing vocabulary by rote. To experiment, observe, and reason is considered too difficult for most students.

(b) The ability to abstract develops with age (to a different degree in different individuals). Starting from the concrete and the tangible is essential, especially for young learners. This is particularly true for treating energy, which is a very abstract idea. Thus, for the beginners the more observation and the more experimentation - the better.

(c) Learning takes time, there are no "ten easy lessons on energy." A program whose objective is to give a graduating high school student a general understanding of energy and its implication for society has to be spread over several years to allow for student growth.

(d) to yield a coherent development, such a program must take into account the development of the learner as well as the structure of the subject matter. However, this does not imply that even an elementary exposition of the second law of thermodynamics must be preceded by the study of the first law. The reason is simple; the first law is inherently a quantitative law, the second law is not.

Heating and Cooling
We consider first the process of heating and cooling. When we bring together two bodies at different temperatures, the cooler one will warm up and the warmer one will cool down. Traditionally, this simple effect is sometimes discussed in elementary textbooks in relation to the quantity of heat, heat capacity, and specific heat. However, I have not found any elementary text that in this context calls attention to the qualitative fact that we somehow never observe the opposite effect: two objects at the same temperature becoming hotter and colder respectively. (Whether we talk of two objects in contact or one object and different parts of them, makes no difference.) Yet this simple observation teaches us that if we wish to raise the temperature of an object, we must have another object at higher temperature. Similarly, if we want to cool an object we need another one, which is at a lower temperature. This is why in the old days people put hot bricks or a hot water bottle in their beds, and large blocks of ice in their ice boxes.

If we do not have a hot object available (if heating is desired) then we use an instrument, a gadget, that will make some object hotter than the surrounding which is to be heated. This can be a stove, or an electric heater, for example. However, a stove needs fuel, such as wood, coal, or oil; the electric heater has to be plugged into the wall outlet, and this will not be enough unless that outlet is connected to a power plant, and the power plant uses fuel.

The same is true if we want to cool something, such as air in the room or food. If we do not have an object at a lower temperature, we need a device such as a refrigerator or air conditioner; and they need fuel. (Thirty years ago there were gas refrigerators in use.)

It is likely that junior high school students will associate the word "fuel" only with substances that burn such as wood, gasoline, etc. To give the term a broader meaning and at the same time provide a useful experimental tool, it is worthwhile to introduce a "power plant" made of a battery of Daniell cells. The "fuel," that is, the substance that is visibly consumed, is zinc. Daniell cells are easy to construct: all that is needed is a styrofoam cup, a piece of parchment paper and some glue. In addition, one needs zinc and copper electrodes and $ZuSO_4$ and $CuSO_4$ solutions.

Expansion of a Gas
The reverse process of the equalization of temperature is not the only process that does not occur spontaneously. Consider two containers filled with air at the same temperature. They are connected with a valve. Suppose that initially the valve is closed and the pressure or densities of the air in the two containers are different. When we open the valve air will flow from the high density side to the low

density side until the densities will be equal. This happens will all gases irrespective of the size of the container. In fact, one container may be a balloon and the other container may be the entire atmosphere. In this form the phenomemon is very familiar.

Again, we should point out that we never observe the process to go the other way, starting from equal pressures and ending with different pressures in the two containers. This teaches us, in analogy with the case of heating, that if we want to add air to a container, we need another container with air at a higher pressure. If we do not have such a container, we need a gadget, called a pump or compressor. But a pump, like a heater or refrigerator needs fuel. Students will be familiar with hand pumps for bicycles or soccer balls, or with the air supply at automobile service stations where air is stored at high pressure.

Depending on the students' familiarity with the rudiments of the atomic model of matter, one may (although it is not necessary for the continuity of development) raise the question of what prevents the air from flowing from the low density to the high density. A simple demonstration based on the idea that a gas consists of a large number of small particles bouncing around freely will make the point. We need an air table with floating discs. We draw a chalk line across the middle of the table. Above the line we mount a piece of wood holding a tight wire to act as a temporary divider. We start with a few discs in one half of the table, remove the divider, and measure the time it takes until all the discs are again in the original half ten times. The reason for timing ten returns is to average out the fluctuations. To answer the question "How does the mean return time depend on the number of discs?" we measure the time of ten returns for 1, 2, 3,... discs. This experiment has been done many times in PS II classes; no class went beyond 8 discs.

The main lesson taught by this class experiment is that there is really nothing that forbids, say, 100 discs to congregate in one half of the air table. It is just extremely unlikely. This becomes apparent when one realizes that after the discs have been bouncing around for a while they are more or less uniformly distributed over the table and are just as likely to move in one direction as in any other direction. For the discs to congregate "voluntarily" in one half of the table requires that on the average more discs will move one direction than in the opposite, and this is very improbable. The average return time for 100 discs would be - 10^{15} years).

Expansion of a Solute in a Solution
We can capitalize on these simple ideas by observing solutions. A solute in a solution behaves in many ways like a gas. For example, a blue droplet of $CuSO_4$ placed in a glass of water will spread out until it is uniformly distributed, moving always from higher concentration to lower concentration. We never see a uniformly blue solution become more concentrated at one place and less concentrated at another place just by itself.

Separating a dilute solution into a concentrated solution and a pure solvent is often very disirable. Sometimes we may be interested in the pure solvent, such as in the case of desalination of sea water; other times we may be interested in the concentrated solution, such as in the case of maple syrup. Unfortunately, these processes do not happen by themselves; to separate a dilute solution into a concentrated solution and pure solvent takes a gadget, such as a heater and a condenser, and the gadget requires fuel.

It is worthwhile to note at this point that although the sponteneous equalizing of temperature and the equalization of pressure or density, and the absence of the reverse processes do not seem to be related, one actually mandates the other. For example, if we could have spontaneous heating and cooling, we could use the hot side to produce steam to compress air without using up fuel. Conversely, if we could have air build up pressure in one vessel at the expense of the pressure in another vessel, we could use the high pressure side to run a refrigerator.

Products and By-products
The various fuel consuming processes which we have discussed so far are all made to take place for a purpose. They are carried out with a device for a specific purpose of product. However, each device also produces some side effects or by-products.

If the students are not aware of the fact that fuels cost money, and that fuel reserves are limited, then this would be a good time to bring these matters up. Once the fuel problem is appreciated the question of how to get the most product and the least by-product out of a given amount of fuel can be raised. Some qualitative considerations, and a simple experiment can lead to surprising conclusions, at least as far as the students are concerned.

Let us start with a wood burning stove. Naturally, we want as much heat as possible to stay in the room. Since oxygen must continually reach the burning wood, one cannot just close off the chimney. What can be done is to cool the gases in the chimney as much as possible and heat more of the house at the same time. Whatever the configuation of the chimney may be, whether a simple vertical structure of a complicated heat exchanger, the gases will cool off to a lower temperature if they spend more time in the system, because cooling takes time. Thus a small fire causing only a gently flow of gases in the chimney will heat the house more for the amount of wood burned.

A deeper insight into the role of the rate at which a process takes place can be achieved by studying the electrolysis of water. The product in this case is hydrogen and oxygen. If we use a battery of Daniell cells as a power plant, then the fuel will be zinc. For a given configuration of the electrolysis cell one can show that with more Daniell cells in series, we can electrolyze water faster. However, we shall get less hydrogen and oxygen for the same amount of zinc consumed. To get the largest amount of hydrogen and oxygen out of, say, 1 g of zinc we have to use a battery which will produce the gases as slowly as possible. We can summarize these observations by saying "slow is beautiful" or "slow is efficient."

It should be noted in passing that living organisms are very efficient users of fuel (glucose) and indeed work rather slowly. When forced to work fast the efficiency goes down.

I believe that the qualitative development of ideas which I outlined provides a sound background for a quantitative study of various forms of energy and the law of conservation of energy. Once this meant a reasonably detailed study of Newtonian mechanics with extensions into non-conservative forces. However, in the middle 1960's the Physical Science Group embarked on a project in which the quantity of heat and electrical work were the starting concepts. The results are published and I will only give the references ([1, 2, 3])

Free Energy
Independently of any particular approach to the law of conservation of energy, the confused students will ask "If energy is conserved, why all the fuss about conserving energy?". The more critical students will realize that the fuss is about conserving fuel (in the sense of using as little as possible), and that energy takes care of itself. However, these students should be encouraged to wonder whether fuels are

related to a special kind of energy, the kind of energy, which, in conjunction with specific devices, can do work. For some classes of processes this kind of energy is the free energy. For systems at constant pressure it is defined as

$$G = H - TS,$$

where H is the enthalpy, T = the absolute temperature, and S - the entropy. ([4]) Obviously, as the definition suggests, the study of free energy has to be preceded by the study of entropy, a topic well covered in the textbook literature. (For an unorthodox approach, see the PSSC Advanced Topic Supplement. ([5])

What is the advantage of introducing the free energy? It is well known that the direction in which a spontaneous process proceeds depends on the total change in entropy everywhere. We can get the same information from the change in free energy of the systems of interest only. To see this, let us consider some process that takes place in a vessel, which is in contact with a heat bath at temperature T. The only interaction between the vessel and the bath is the heat flow. Then the total change in entropy

$S = \Delta S_{system} + \Delta S_{BATH}$ with $\Delta S_{BATH} = \frac{Q}{T}$ where Q is the heat added to the bath system

hence: $T\Delta S = T\Delta S_{system} - \Delta H$ Thus at constant temperature $\Delta S \geq 0 \rightarrow \Delta G \leq 0$

Looking at energy changes this way will reveal to students that while the total energy involved in processes consuming fuels indeed remains constant, the free energy is always decreasing. As we deplete various fuel resources, whether chemical or nuclear we are depleting the reserves of free energy.

Furthermore, the amount of fuel reserves by themselves is not the only relevant parameter. Their concentration must also be taken into account since just concentrating any substance, i.e., reducing its volume, requires free energy.

To sum up, I suggest that Energy Education as part of science education start with processes that take place by themselves, with emphasis on the observation that reversing such processes requires a fuel consuming device. This can be done in a qualitative way using mainly everyday language. After the study of the conservation of energy as part of a physical science, physics or chemistry course, the second law of thermodynamics, as formulated in terms of free energy should be given more prominence than is the case today.

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7.3 INVITED

HOME HEATING: COMPUTER ASSISTED LEARNING APPLIED TO ENERGY EDUCATION

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Abstract

The use of Energy Audits as an educational strategy is becoming increasingly common. *Home heating* combines some of the objectives of an energy audit in a real domestic situation with the opportunity to answer the question "What would happen if...?", that is, to find out very quickly what effect changes in some of the parameters of the dwelling under investigation (construction method, choice of fuel, etc.) would have on energy demand and fuel bills.

Computer Assisted Learning

Home heating' is one of the Computer Assisted Learning packages produced by the Schools Council's *Computers in the Curriculum* Project based at Chelsea College. The aims of this project have been to explore ways in which the computer can contribute to the learning of different topics in several subjects at secondary school level (11-18 years)·. The material produced is intended to supplement the normal teaching, not to replace it. Nor has the project tried to introduce new topics into the curriculum, but rather to try to make more effective the learning of topics which are already taught. Such a topic might be one in which for reasons of time, cost, danger and so on, students cannot carry out their own investigations. Most elementary science courses include some mention of and simple investigations into the transfer of heat energy and the thermal properties of different materials.[1] In Britain this work might typically be done by 12-14 year olds. The teacher might well follow the experimental work with a mention, but perhaps no more, of the effectiveness of various forms of insulation and of the fuel savings that would ensue from more efficient insulation of our homes. The CAL unit *Home heating* might well be introduced at this stage to allow students to investigate these effects, as they relate to their own homes, in some detail. The work links the somewhat artificial experiment in the school science laboratory with the real world of the students' homes (and their parents' bills), and furthermore it deals with a subject whose importance they should recognize because of its increasing prominence in the public media.

An important feature in the design of these CAL packages is that the students' activity does not consist only of work at the computer: some preparation is usually needed beforehand, and some follow-up afterwards.

All the packages consist of written material for teachers and students as well as computer programs (written in BASIC) and program documentation.

Home heating is one of the most ambitious of these packages and is intended for use at a variety of levels in British secondary schools. To allow for this flexibility of use the program itself can be run in four different modes of increasing sophistication.

Teachers' and students' notes

The teachers' notes include suggestions as to how the unit can be incorporated into the teaching of a variety of subjects at different levels: a certain amount of detail of the physics of the computer model which is intended as background material for teachers: information about the data used in the program and its sources is included. The students' material includes a series of five worksheets which could be used if necessary to help establish the ideas which must be understood before the program can be used. Another worksheet asks students to list the kinds of heating appliances used in their homes, the types of fuel used, and encourages them to find out the power rating and running costs per hour of each one.

Using the Computer

The sixth worksheet 'How to use the program HEATER for the first time' requires students to collect certain information about their homes including area of walls, windows, etc. and inside temperature.

When using the program for the first time the student is asked a limited number of questions if he cannot answer any of these questions he can reply with -1 and the computer will assume a typical "default value." The student is informed of the value assumed in this way. When he has input the required information the student is offered a choice of three kinds of results. These are:

1. Rate of heat loss as a function of outside temperature.
2. Rate of heat loss plus heating cost per hour.
3. Annual costs.

As with all the CAL units developed at Chelsea the student is encouraged to interpret the results he gets from the computer and to use them to answer specific questions. (What makes some houses lose heat more quickly than others? Does it cost more to make the inside of a house warmer? and so on).

Clearly the computer program makes a lot of assumptions in working out results from the data supplied in answer to the limited number of questions asked in the FIRST use of the program. The final worksheet is called "Windows, Walls and Roof — a second use of the computer." This introduces a longer dialogue in which a student is also asked for information about the construction of the walls, windows and roof of his home. At this stage the student is given a fairly restricted set of possibilities to chose from corresponding to the most common types of construction in Britain. When using the program in this way the student is told to try to reduce the cost of heating the home by changing the construction methods, and to compare the cost of different forms of insulation with the reduction in fuel bill achieved.

Flexible use

The FIRST and SECOND modes of use discussed above do not exhaust the possibilities of the program. Its full versatility becomes apparent if it is used in PRELIMINARY mode. This allows the user to choose what factors he wants to investigate using a series of "command words" and codes.

The commands and codes are explained in a series of leaflets intended for the more advanced students who would use the unit in this way.

The use of "command word" rather than the dialogue form familiar in much computer based learning makes for much more flexible, and student-directed use. It encourages the student to investigate the effect of changing only one parameter at a time and makes it easy for him to do this.

It is not necessary in this mode to specify all the parameters in the model. Once again a default value will be assigned to any that have not been specified by the user. The command word LIST will cause the computer to print out a complete description of the dwelling as currently defined, including any assumed default values.

The computer program HEATER and the associated data files, etc. are available on punched paper tape for main frame computers and on mini floppy discs for several of the most popular microcomputers. Future plans include a smaller version of the package, suitable for junior schools with a program on cassette tape.

Footnotes

1. R.D. Masterton, and R.E.J. Lewis (eds) HOME HEATING, (Schools Council/Edward Arnold, London, 1979). The complete package consists of *Teachers' notes, Students' worksheets, Students' leaflets, Program documentation* (by P.W. Smith) and software.
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7.4

ENERGY AND THERMODYNAMICS IN THE HIGH SCHOOL CLASSROOM

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Introduction

The Inclusion of a section on classical thermodynamics in a high school course presents several problems for both the teachers and the students. The traditional methods of discussing the first and second laws of thermodynamics using mathematical notation and introducing parameters such as enthalpy, free energy and entropy seem to give rise to serious difficulties at this stage and do not provide sufficient interest for the students. However, it is apparent that many everyday examples such as the principles of the internal combustion engine, power plants, and the combustion of food in the body all involve energy conversions which, in turn, are determined by thermodynamic principles.

One interesting way to approach the subject of thermodynamics at the high school level is to examine the overall energy picture for the United States including the various energy inputs in terms of Quads being directed to various energy uses such as electric energy generation, residential and commercial use, industrial use and transportation. All these energy demand areas involve energy conversions and the first point to emphasize from this overview is that some energy is lost in the conversions and only some of the energy is converted into useful work.

This should provide a springboard to raise several questions as to what is energy and what are the principles governing energy conversions. In addition, the concept of Quad of energy [1 Quad = 10^{15} BTU], some discussion of the various energy sources and an appreciation of how energy is used can be presented at this time.

Energy conversion and the first law

The First Law of Thermodynamics forms the basis for understanding the operation of energy conversion devices. A good example to illustrate various energy conversions is that of the generation of electrical energy in a nuclear or fossil fuel power plant. Some discussion of these processes would introduce the concepts of energy and work and, at this stage, it is important to clarify the meaning of some of the important terms invovled in energy conversion.

A. ENERGY AND ENERGY CONVERSION

For a full understanding of the term energy, the problem would have to be examined in terms of molecules and atoms in motion and the mathematical analysis of this problem is not particularly easy at the high school level. Most textbooks mistakenly define energy as a measure of the ability of the system to do work and usually is considered as a general term which embraces all kinds of work, e.g., mechanical work, electrical work and chemical work. It is easier for the students to understand energy in terms of what it can do rather than what it is. At this stage it is useful to perform some demonstration experiments in order to reinforce the concept of energy. Examples of possible experiments include

- windmill (potential energy — mechanical energy)
- solar cell (solar energy — electrical energy)
- simple steam turbine[1] (heat energy — mechanical energy)
- simple chemical cell involving copper and zinc electrodes immersed in solutions of copper sulfate and zinc sulfate separated by a salt bridge and connected to a light bulb (chemical energy — electrical energy)
- simple chemical decompostion, e.g., heating ammonium dichromate on an asbestos board (chemical energy — heat energy).

These demonstrations will help the students to recognize energy in various forms such as radiant (light), thermal (heat), chemical, nuclear, mechanical and electrical and also that energy can be changed from one form to another. An *energy conversion device* is any device whose purpose is to change energy from one form into another form, which is more convenient or useful.

B. HEAT, WORK and THE FIRST LAW

Before formulating the First Law of Thermodynamics, it is preferable to examine the physical concepts of heat and work in more detail. Some familiar examples of heat are i) the process of combustion, whether in an oil or gas fired home furnace or in the body (combustion of sugars, or ii) the heating of water in a hot water system. Some simple heats of mixing experiments should be introduced using cubes of different metals and several liquids to illustrate that the amount of heat necessary to obtain a given temperature change is dependent upon

- the amount of the substance
- the temperature rise
- the nature of the substance

These experiments form the basis of establishing the simple relationship that is used in any calculation involving heat, namely,

$$\text{Heat} = m \times c \times (T_2 - T_1)$$

where m is the mass of material, T^1 and T^2 are the initial and final temperatures respectively, and c is the specific heat of the substance. Examination of equation (1) leads naturally to the definition of the *specific heat of a substance which is defined as the amount of heat required to raise the temperature of one gram of a substance by one degree.*

At this juncture, the units in which heat is measured could be introduced, i.e. calories, Joules and the BTU (British Thermal Unit), along with their definitions. Simple problems involving conversions of units and temperatures scales would be appropriate.

One way of introducing the concept of work is to consider the combustion of food in the body which not only produces some heat, but also yields some ability to do mechanical work (i.e. movement of arms, legs, etc). Another example of a system that produces work is that of a gas or vapor being heated in a confined space (e.g. a turbine or internal combustion engine). The expanding gas pushes against the surrounding and moves the piston a certain distance. The definition of work can be introduced as:

Work = Force x Distance

In addition to heat being converted into work, the heat can also cause the motion of the atoms or molecules of the substance to change, i.e. the temperature will increase. The translational (kinetic) energy will increase with an increase of temperature. Also, molecules will begin to vibrate more vigorously and their rotations will increase. In other words, the input heat will change the energy of the substance (gas, solid, liquid). The effects of temperature on molecular motions can be demonstrated very effectively with the use of molecular simulators which are commercially available or through the use of computer graphics.

After introducing the concepts of heat and work through discussion, experiments and demonstrations, the time is now right for introduction of the First Law of Thermodynamics.

Internal Energy = Heat + Work

$$E = Q + W$$

Although energy can be converted from one form into another, energy must be conserved in this process. Several different energy conversions are needed to convert the fossil fuel energy or nuclear energy into electric power. During each conversion, varying amounts of the energy are transformed into waste heat. In particular, the operation of a turbine produces a large amount of waste heat. The question as to how much heat is converted into work or vice-versa (i.e. the efficiency of the process), is not answered by the First Law. This will be discussed via the Second Law of Thermodynamics.

The First Law of Thermodynamics is a statement of the Law of Conservation of Energy, that is, "Energy can neither be created nor destroyed, only converted from one form to another." It follows from this statement that, "Energy may be transferred from one source to another." "Energy may be stored and later released in a different form." In real-life terms, the First Law can be expressed by such saying as "You can't get something for nothing." "You can't get ahead." "You get what you paid for."
This is obviously part of our energy problem. Our energy consumption is limited by the available energy sources. One can not simply create energy out of nothing, whenever it is desired or needed. All of the above statements concerning the First Law should be discussed carefully so that the students can begin to get a feeling for the Law.

Thus, the First Law allows the operation of energy conversion devices, so that, for example, a fixed amount of mechanical work can always be converted into the equivalent amount of heat. However, the study of utilization of energy such as a heat engine demonstrates that the reverse process cannot be accomplished; that is, a fixed amount of heat cannot be completely converted into the same amount of mechanical work, as some of the initial energy is unavoidably wasted.

Energy conversion and the second law

Energy conversions are not necessarily exactly reversible, but there is some directionality in naturally occurring processes. The First Law does not shed any light on this matter. It is the Second Law of Thermodynamics that indicates which processes can occur naturally.

A prime example of one of the most important types of energy conversion devices is known as the heat engine. A heat engine converts the input heat energy into mechanical energy (e.g. turbine in a power plant) as the useful energy output. Waste heat is rejected from the heat engine as a result of the energy conversion.

A fairly detailed description of a power plant is appropriate at this point and should be combined with a visit to a local power plant, or if that is not possible, representatives from such a plant should be invited to discuss the plant operation with illustrated slides or movies. Several different energy transformations are needed to convert the nuclear energy or the fossil fuel energy into electric power. The first energy conversion device depends on whether it is a fossil fuel-fired plant or a nuclear power plant. Otherwise, the two types of plants are made up of analogous energy conversion devices. The source of the thermal energy necessary to produce steam is a chemical reaction (the burning of a fossil fuel) or a nuclear process (the splitting of an uranium atom). The thermal energy is absorbed by the water in the boiler, transforming the water into high pressure steam which is piped into the turbine where some of the thermal energy is converted into mechanical energy (work).

The energy which remains in the steam that was not converted to work in the turbine is passed as waste heat from the turbine in the spent steam. This steam must be converted to water using a condenser before returning to the boiler to go through the power plant cycle again. The condenser is a heat transfer device through which cold water is piped, picking up the waste heat which causes the water to increase in temperature by about 10-20 degrees. This warmer water is returned then to its source, usually a lake, river or ocean, causing thermal pollution of the body of water. More recently, especially where bodies of water are not available, cooling towers are being used to dissipate the waste heat.

The mechanical energy produced in the turbine is transmitted through a shift into an electric generator where it is converted to electric energy by means of a coil moving in a magnetic field. Essentially a steam turbine is a pinwheel driven by high-pressure steam rather than by air. It basically consists of a rotor from which project several rows of blades over which the steam flows, causing rotary motion and the conversion of some of the energy in the high pressure steam into mechanical energy (work). Other sources can be consulted for more information on turbines.[2]

There are many different ways of expressing the Second Law. Consideration will be limited to those which are relevant to this level of presentation.

The Second Law deals with the directional flow of energy, i.e. which way will energy flow spontaneously, demonstrating that the law of conservation of energy (i.e., The First Law) is not enough. The Second Law can be expressed as follows:

"Naturally occurring processes are those which can proceed in a spontaneous manner and are irreversible."

There are several spontaneous processes with which we should be familiar. For example, water flows downhill, but not uphill. After a fire has burnt the ash cannot be returned to the original starting material (e.g. coal), the process is irreversible. An automobile rolls down a hill and then is driven back to its original position (assuming no mishaps to the car). Isn't this a reversible process? No, it is not, unless the emitted fumes can go back up the tail pipe to the engine where the gasoline and oxygen are restored, etc. Or, you can not run a car on pollution!

One knows intuitively that heat flows from a hot body to a cold body, so that the directionality of energy flow can also be expressed as *"Heat cannot spontaneously pass from a colder body to a warmer body."* Thus, a block of ice placed on the kitchen table will melt by taking heat from the surroundings, but a pool of water on the same table cannot form ice spontaneously and give heat to the surroundings. Evaporation of a liquid from a surface occurs by taking heat from the surface, thus cooling the surface.

A power plant uses the directional flow of heat to create electrical power. This direction of flow can be created by having a warmer area at T_2 and a colder area at T_1, where T_2 is greater than T_1. In an actual power plant, T_2 corresponds to the temperature in the boiler and T_1 corresponds to the temperature of the river or lake, which provides cooling water for the condenser. The flow of heat would cause the temperature of the river or lake to increase. If this heat is not removed, then T_1 will approach T_2 and the output of power will stop. As long as the condenser can remove heat from the steam, thus condensing it back into water, T_1 will not increase and power can be generated.

There are other statements of the Second Law which refer more specifically to the production of waste heat during an energy convesion, and to the operation of a heat engine. For example,
"All energy conversion processes involve the production of waste heat, and reduce forever the amount of useful energy available."

"Energy conversions are not totally efficient."

"You can't even break even."

Thus, all energy conversions occurring in a typical power plant must involve formation of waste heat, since no conversion is perfectly efficient. The most inefficient of the energy conversions is the conversion of thermal energy to work in the heat engine (i.e., steam turbine), where approximately 50% of the thermal energy is converted to work and the remaining thermal energy converted into waste heat.

"There is a general tendency in nature for energy to pass from a more available form (i.e., ordered) to a less available (i.e., disordered) form."

Some other important and interesting examples of efficiency in energy conversion processes are those following the complete processes of (a) extracting crude oil through to the movement of an automobile and (b) the mining of coal through to the production of electricty in a power plant. These examples should make it perfectly clear to the students that some of our common everyday practices are very inefficient.

The concept of limited efficiency of heat engines was first presented in 1824 by an engineer named Carnot (who was 19 years old at the time) who showed that the efficiency of conversion of thermal energy to work was related to the operating temperatures, as follows:

$$EFF = \frac{T_{HOT}-T_{COLD}}{T_{HOT}} \times 100$$

where Thot is the temperature of the heat reservoir (i.e., boiler) and Tcold is the temperature of the heat sink (i.e., the temperature of the cooling water). E.g., if Thot = 600° K, Tcold = 300° K, then 50% of the heat energy is converted into mechanical energy and 50% into waste heat. Inspection of equation 4 shows that the efficiency is independent of the nature of the working fluid. Note that the loss of energy due to friction is not included in the above consideration. Using the temperatures representative of the steam and the cooling water in the fossil fuel-fired power plant (590° C and 20° C) and the nuclear power plant (315° C and 20° C), the efficiencies for the two power plants are found to be

Fossil Fuel-Fired Power Plant: $Eff = \frac{(590+273)-(20+273)}{(590+273)} = X100 = 66\%$

Nuclear Power Plant: $Eff = \frac{(315+273)-(20+273)}{(315+273)} = X100 = 50\%$

That is, there is a significant difference in the efficiency of conversion of thermal energy to work in two types of power plants.

Another way of viewing the Second Law considers the concepts of order and disorder (or chaos). For example, a brand new deck of playing cards is arranged by rank and by suit. This can arbitrarily be defined as an ordered system. Throw this deck of cards into the air and let the cards fall in a random fashion on the floor. The original order of the deck of cards is lost and the new arrangement is a random choice from many possible orderings of the deck of cards. The process by which an ordered system has been transformed into a "disordered system" was a spontaneous one. Further, the reverse process cannot occur (without using energy). Again, the Second Law dictates the directionality of naturally occurring processes, that is, "Spontaneous Processes Tend to Produce Disordered Systems."

One can also introduce a little of the philosophy of the Second Law of Thermodynamics by considering the earth in a thermodynamic sense. Here it must be concluded that, in spite of all the technological innovations leading to the creation of apparent order (e.g., buildings, cars and spaceships), nature is gradually moving towards a state of disorder within the universe as a whole. Thus, the creation of wastes such as pollutants,[3] or the gradual exhaustion of the world's resources of oil and coal would be examples of the Second Law of Thermodynamics. Thus, in a thermodynamic sense, the soothsayers who say "Repent now, the world is coming to an end" are technically correct. Only their time frame is off. One can then conclude from the two laws that you can't get something for nothing, and you can't even break even.

In conclusion, we feel that the inclusion of the concepts, experiments and examples discussed above will give the high school student a sound introduction to the ideas of the First and Second Laws of Thermodynamics and therefore equip the students for a more mathematical approach at some later stage.

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7.5

CLASSROOM CONSTRUCTION OF APPARATUSES USING RENEVABLE ENERGY SOURCES: A MOTIVATIONAL APPROACH TO ENERGY EDUCATION.

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Introduction

Science teaching is based, at least in Italy, on a simplified "reconstruction of scientific thought," which often misrepresents its actual history, by eliminating all the technical, cultural, and economical aspects of the problems which gave raise to its development, with the purpose of presenting a purified and neutral picture of science.

A gap between the subjects included in the standard curricula, and the topics of more practical and social interest which would better stimulate the attention of students, is therefore a consequence of the structure and methodology of this kind of science teaching.

The eduational experience discussed in this paper, assumes as starting point the need to cope with this problem, particularly for low ability students, and follows a line of research grounded on two basic assumptions:

i) the approach to a scientific problem should always take into account the practical problems arising from its social use;

ii) the proper understanding of concepts can only be attained by experiments, their validity through planning and realization of definite applications.

Following these premises we have chosen to concentrate on the problem of energy education as a subject of our research group of the "Laboratorio di Didattica delle Scienze" of Rome University†.

In this case, in fact, the above mentioned gap is particularly evident: while the discussion on energy crises and consumptions goes on every day and everywhere, in school students learn almost only energy conservation, with little or no reference to energy downgrading, without ever being taught to connect the abstract scientific concepts to the problems in which their use is required.

Planning as classroom work

We have decided to present in two high schools of Rome †† the problem of the present energy crisis, starting from an analysis of the world energy balance with the purpose of discussing possible solutions.

The first stage of the work has been therefore devoted to acquire several information through seminars on definite subjects prepared by working groups sometimes with the help of experts.

The result of this preliminary discussion has been the decision to focus the bulk of the work on the study of renewable sources, through the planning and the construction of small scale apparatuses with the aim of testing the possible practical use of this kind of resources.

It was agreed that the projects elaborated by the students should respond to the following requirements:

i) to deal with a single concrete problem: e.g. the possibility of heating water on air by means of solar radiation;

ii) to envisage the performance of measurements or semi-quantitative controls, in order to verify the correspondence between goals and achievements and compare the results of different projects;

iii) to plan the use of currently available materials and simple technologists with the purpose of realizing entirely the construction at school, with a minimum of external aid. The following apparatuses have been realized by the working groups during a year (with 3 work hours/week):

a) *Different types of flat plate collectors.*
The heat absorber consisted of blackened copper tubing or radiator elements, and the storage unit was made of insulated cans or tanks. Thermometers were placed at the inlet and the outlet in order to compute and compare the efficiencies of the different heaters.

b) *Different types of air-heating solar collectors.*
The absorber surface was increased by means of an array of beverage cans. The inlet and outlet air temperature has been measured. However, the difficulty in measuing the flux made the computation of the efficiency only qualitative. The purpose of the model in this case was mainly to study the properties of air as a heat-carrying fluid, in view also of its application to the heating of buildings.

c) *Parabolic cylindrical concentrating collectors of various sizes.*
The purpose of the model was to investigate the convenience of using this device for small scale, low-temperature water heaters.

The efficiency of the apparatus was compared with that of flat plate collector, taking also into account the cost of the orienting device which is needed in this case.

The common background of all these measurements has been provided by the evaluation of the incoming solar energy flux, performed by means of a calibrated photovoltaic cell.

These data have been supplemented by measurements of maximum solar attitude at different times of the year.

d) A biogas generating plant.
The gas produced by ordinary food-waste has been collected in a water-filled flask, and burned, in order to evidenciate the presence of methane. The quantity of CO_2 contained in the gas, the nitrogen enrichment, and the microbic increase of the residuals have been measured.

e) A model of energy self-sufficient house.

The architectural features of the house are planned both for achieving energy saving and use of renewable sources. The first one is obtained by means of adequate orientation, suitable roof overhand, and the choice of appropriate building materials. The second ones are favored by a correct roof inclination for the installation of water heaters and photovoltaic collectors, the use of "green house" elements for air heating, and the inclusion of heat-storage walls. The thermal conductance of building materials has been measured by means of a thermally insulated box which loses energy through one of its walls.

Conclusions

From this experiment, mainly performed during vocational area time, we have been able to draw the following conclusions.

The first, and the most important one, consists in the acknowledgement that the introduction of a "planning focused approach" changes completely the teaching methodology.

The students, in fact, for the first time, had to face a practical situation with the task of producing viable solutions. This means:

a — to identify a limited problem;
b — to collect information and data, of scientific as well as technical and economical nature;
c — to chose the dimensions, materials and tools to be used;
d — to build practically the apparatus and test its performance;
e — to work out possible improvements in order to find the best economical and technical compromises.

The difference with ordinary laboratory work should be stressed. In this case, in fact, the task to be accomplished is very different, because neither the goal, nor the procedure to attain it are predetermined in advance.

This new methodology has three important features. The first one is given by the integration of manual and intellectual activities. Even the low ability students, in this way, become involved in this type of work, discovering their manual and technical skills, which usually our traditional school does not appreciate.

To fill the gap between the life time dedicated to learning and the one in which the acquired notions are applied is the second important feature of this method.

The third feature is the change in the teachers role, which becomes that of a coordinator, and organizer of the common work even without necessarily posessing all the relevant expertise.

For what concerns the knowledge acquired by the students we have already pointed out the advantage of filling the gap between the curricular contents and the technical and scientific problems of everyday life. I want to stress that his advantage does not entail a substantial loss of the scientific information imparted.
In fact we have treated in sufficient detail the main topics of thermology, and geometrical optics, together with more restricted arguments such as emission and absorption of radiation, fermintation chemistry, electrical circuits, etc..
Furthermore the concept of energy has been developed under many different perspectives, including energy transformations, energy conservation, downgrading of energy, energy sources and consumptions.

At this stage the need arises of planning some curricular units intended as support of this kind of activity. We are starting to work in this direction and we are at present experimentating an introductory unit on energy transformations. A second interdisciplinary unit on "energy sources," is being prepared, integrating concepts of physics, mathematics and chemistry.

7.6

A PHYSICAL SCIENCE COURSE FOCUSED ON ENERGY

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Abstract.

Many people agree that education about energy is important for an informed citizenry. Most efforts in energy education at the secondary level have been achieved through "infusion" into existing courses. My search for a way to give energy education the focus I feel it truly deserves has led me to offer a physical science course focused on energy for the past three years at the Calhoun School. This course, "Energy for the Future," offers students a way to learn much of the material from a traditional 9th-10th grade physical science course in a way that is much more relevant to their daily lives and some of the future decisions they will face.
After beginning with a historical overview of our energy use in the past, the course turns to our energy sources of the present and prospects for the future. Political and economic considerations are included as well as scientific and technical considerations. Students learn from films, games, and field trips in addition to reading, written assignments, and laboratory experiments.
Although courses on energy abound at the college level, a greater standardization of curriculum seems to have made "infusion" a more practical approach at the secondary level. The experience of teaching an energy-focused physical science course at the secondary level is presented as an alternative to "infusion" in the hope that others might be stiumlated to teach an energy-focused course themselves.

Text.

One goal of education is to prepare our students for the future. Included in that education is usually at least one science course. For students who do not go on to become scientists, it is increasingly important that their science courses focus on ways in which science is expected to affect their future. One topic which is both relevant in our everyday lives and transcendent among all the sciences is energy. Many approaches have been taken to educate our students about energy, such as the National Science Teachers Association's Project for an Energy Enriched Curriculum (PEEC) and energy education curricula developed by various of the United States. These approaches have been mainly to "infuse" energy topics into existing courses.

While "infusion" of energy topics is better than ignoring them, I feel that the "infusion" approach does not give energy the focus it truly deserves in the curriculum. I would like to describe for you my preferred alternative: "Energy for the Future," a physical science couse refocused on energy.

"Energy for the Future" was not my idea alone. In fact, it wasn't evey my idea at all. For several years I had been teaching at The Calhoun School, an independent school on the Upper West Side of Manhattan. Eugene D. Ruth, Jr., who then headed Calhoun, continually emphasized the importance of educating our students to prepare them for the twenty-first century. In response to this I had already been teaching about energy in team teaching situations for three years. Then, in the spring of 1978 I found myself at a conference sponsored by the National Energy Foundation asking the question, "Should energy be taught merely as a topic infused into existing courses or should it be given the focus of its own separate course?" The answer — and the idea for "Energy for the Future" — was provided by my friend Lys Keneally Waltien of John Adams High School: why not restructure the tradiational physical science course with a focus on energy?

I have taught "Energy for the Future" for each of the past three years to mostly 9th and 10th grade students at The Calhoun School. In the first and second of those three years I relied on existing materials, especially those from DOE and PEEC, pieced together in the way I felt the course should be organized. In the second year I also wrote my own text, which was then ready for students to use in the third year.

The list of chapter titles below also indicates the structure of the course. I begin with a historical overview, which was inspired by George Russell Harrison's *The Conquest of Energy.*[1] Harrison characterizes the evolving stages of humankind by their sources of energy: food (hunting and fishing), food (agricultural), fuel (industrial), fission (modern), and fusion (future). This also allows for some experiments to teach the basic physics of energy: the heat content of food (and the measurement of heat by the increased temperature of a known mass of water); the work done by lifting an object the same height above the ground in four different ways; the basic elements of electromagnetism; and the conversion of electrical energy into heat. It also provides a natural form to teach the first and second laws of thermodynamics.

1. Food: Our First Energy Source
2. Using Energy to do Work
3. Finding Another Way to do the Work: The Industrial Revolution
4. Converting Energy from one Form to Another: The First Law of Thermodynamics
5. Some Forms of Energy are More Useful than Others: The Second Law of Thermodynamics
6. Electricity: Capstone of the Industrial Revolution
7. The Formation of Fuels from Fossils
8. Atoms
9. How Electrons Behave in Atoms
10. How Atoms Combine
11. Energy Storage in Fuels
12. Nuclear Power Plants
13. The Nuclear Fuel Cycle
14. The Kinds of Fuels We Use Today
15. The Environmental Impact of Goal
16. Nuclear Power Plant Safety
17. Handling Nuclear Wastes
18. The Breeder Reactor
19. To Breed or Not to Breed
20. Nuclear Fusion
21. Solar Heating
22. Other Sources of Heat (Solar Thermal Electric, OTEC, Geothermal)
23. Direct Conversion of Sunlight to Electricity
24. Sources of Mechanical Energy (Wind, Water, Tides)
25. Biomass
26. Synthetic Fuels
27. Other Ways to Store Energy
28. Energy Conservation
29. What Kind of Energy Future?

In order to discuss the types of fuel used today (both fossil and nuclear), I then turn to atomic, molecular, and nuclear structure. This is followed by a confrontation with our present patterns of energy production and consumption and an assessment of future supplies of the fuels we have come to rely on.

Having thus brought ourselves into the present, we then focus on the future, beginning with an environmental assessment of the effects of nuclear and coal, the only presently-used fuels that remain in abundance. In light of the realization that both nuclear and coal pose environmental problems and that neither is an unlimited source of energy, we continue by exploring alternative future sources of energy and examine the lifestyles that might be necessitated. Political and economic considerations are included as well as scientific and technical considerations. The conclusion is a series of activities designed to focus on the question posed in the title of the concluding chapter: What kind of energy future?

Because I feel that an important dimension of energy problems is quantitative, written assignments stress problem solving with arithmetic the students should have already mastered. Students in "Energy for the Future" also learn from laboratory experiments, films[2], games[3], and field trips. Indeed (and not surprisingly) these "hands on" and audiovisual activities have been the most popular part of the course.

Because of the topical nature of "Energy for the Future" and the audience to whom it is addressed (students more likely to take physical science than physics and chemistry), I have measured the success of this course not in terms of factual material learned but by its impact on the way my students look at the world about them and their expectations for the future. In one of three possible final essay topics I allowed my students to address this question. Some of the responses, such as greater awareness of the need to conserve energy and a realization that it is their generation whose responsibility it will be to solve our energy problems, are understandably expected. Not quite so expected, and all the more heartwarming, were responses that showed concerns for generations following, commitments to an energy-conserving lifestyle, and awareness of relationships between energy issues and international affairs. Many of the students noted that they felt themselves to be more "energy conscious" than their parents.

Although courses like "Energy for the Future" abound at the college level, they seem to be quite rare at the secondary level.[4] Perhaps this is because the secondary curriculum is more standardized, and "infusion" of energy topics into this standardized curriculum is easier to achieve. I reiterate, though, that "Energy for the Future" is not a new course to be added to the curriculum. Rather, it is a refocused version of an existing course. I present my experience in developing and teaching it in the hope that others might be stimulated to teach an energy-focused course of their own and that a network of communications can be set up among those who do so.

Footnotes

[1] G.R. Harrison, THE CONQUEST OF ENERGY, (Morrow, 1968)

[2] The two sources I have used are 1) DOE TIC Film Library, Oak Ridge Turnpike at Athens Road, P.O. Box 62, Oak Ridge, TN 37830, 615-576-1285; and 2) Shell Film Library, 1433 Sadlier Circle, West Drive, Indianapolis, IN 46239, 317-291-7440.

[3] J.L. Roeder, *Phys. Teach.*, *15*, 428 (1977), *18*, 302 (1980); PEEC, "Fossil Fuels and the Greenhouse Effect," (NSTA, to be published)

[4] For one example, see H. Goldring, "Energy — A 30 Period module for Mixed Ability Classes," in Uri Ganiel (ed.), PHYSICS TEACHING — OSCILLATIONS AND WAVES, CURRENT PROBLEMS, (Balaban, 1980). J.M. Oxenhorn, ENERGY AND OUR FUTURE, (Globe, 1979), addresses the same material that I do, but at a slightly lower level.

7.7

ENERGY SUPPLY BY NUCLEAR POWER STATIONS
AN INTERDISCIPLINARY APPROACH TO PHYSICS TEACHING

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Abstract

We are introducing an approach toward physics education developed at the Institute for Science Education (IPN) in Kiel, Fed. Rep. of Germany.[1] [2] This lecture will illustrate one of five paradigms for science education representing the IPN Physics Curriculum for grades 9 and 10.[3]

- Education is an integral move of a society to secure its survival: The move has to be toward dynamic change.
- The young are influenced, often forced, toward system conformity or fit. The influence has to go toward system-consciousness.
- A democratic society requires members of high qualification, self-confidence and responsibility: The requirement is one of creative solidarity against misuse of social power.

We, therefore, consider it an educational must to deal in our schools with issues of our society's future as it is established at present. The tradition of school subjects is not permitted to curtail this task.

Starting the approach with an analytic view of society

Our approach can be shortly characterized by four questions. They reflect education in its cultural context and have delineated the instruction unit we present.

(a) A question of *public concern* and *democracy:*
Our societies proclaim to be democratic, i.e. participation of each member in deciding on matters of public concern is fundamentally guaranteed.

Education has to prepare the young generation for that participation. *Nuclear power* use is of public concern. Government spends large amounts of tax money, it is discussed in political parties; unions as well as industry consider it a vital economic issue.

(b) A question of *controversial interests* and *values:*
In our society people have differing interests and values. So, basically, democratic participation bears controversy and conflict. They are delivered when interests and values clash on vital issues such as scarcity of resouces, inbalance of need satisfaction, or danger of existence. *Education* has to prepare the young to accept controversy and conflict, to identify own interests, develop own values, and handle conflicts. *Nuclear power* use has developed into a major conflict. Heads of political parties and of local government already have resigned, court orders have been released, thousands of policemen and national guard have been activitated, ten thousands of people have demonstrated.

(c) A question of *awareness* and *information:*
Matters of public concern and controversial valuation usually become an issue of public debate, making most members of a society aware of them and requiring their decision on them. Information available tends to influence people. It is modified, destorted, often manipulated and usually hidden in different types of presentation and material. *Education* has to make the young aware of vital issues and prepare them to analyze and handle manipulated information. Information on *nuclear power* is given in different media in a multitude of presentations and it is often highly manipulative.

(d) A question of *relevance* and *scope:*
Wide coverage in public media doesn't guarantee relevance of an issue. Depth and scope of an issue is linked with conflict of interests and values, with threat to way of life, structure of a society or plain survival. *Education* has to prepare the future generation to handle such problems in their totality and complexity. *Nuclear power* use is an issue of high relevance, wide scope and probable lethality.

Consequences for teaching "Nuclear Power Stations"

Nuclear power use has been identified as an important issue in our societies. Education has to pick it up and deal with it. In the Federal Republic of Germany this issue has led to an introduction of the topic "nuclear power" into the physics syllabi of all types of school for grades 9 and 10. About 80 percent of students are leaving school after these grades, at the age of 15 or 16. But syllabi and regular school books are developed according to the disciplinary structure of "nuclear physics." Research has proven the disciplinary approach ineffective. Besides, "nuclear physics" is not the issue, the "use of nuclear power" is. We shall retrace the four questions we have just discussed and illustrate our answers to them with excerpts from our instruction unit.[4]

(d†) What is the *scope* of the issue on nuclear power and what of it is *relevant* for physics education?

A content analysis of 200 representative articles of three newspapers published during one year identified that only 1% of the information on nuclear power was concerned with physics. But percentages reveal neither importance of the given information nor its structure. Further analysis of information linkage and scope showed complex relations.
For instructional purposes we have simplified the structure concentrating on those five aspects which we consider indispensable even if the issue is picked up only in physics teaching.

(c†) How can students sharpen their *awareness* of the nuclear power issue and cope with the *information* made available? Global awareness of the issue was already present. But various, often contradictory information packaged in miscellaneous types of presentation kept students at a distance and from going into depth. They had to be made familiar with the different modes of presentation and to draw information from them. Our unit, therefore, contains excerpts from newspapers and books, diagrams, charts, tables, graphics, pictures, cartoons, and it refers to slides and films. Some of these materials had to be simplified but, basically, they retained their contents and form.

(b†) How can conflicts be analyzed to identify the driving *interests* and *values* involved?
Trials in 21 classes have helped us to develop farily adequate means for analyzing the varied types of information. They also guaranteed that the offered information was comprehensible. In addition to special assignments on information analysis and specific hints on modes of distortion and manipulation, we prepared a scheme for analyzing assertions and claims. This scheme can also be used for working out ones own line of argument.

(a†) How can *public concern* become personal and activate students to *democratic participation?*
Democracy is not a privilege of adults facing children or of socially powerful facing the powerless. It is the continuous struggle of the suppressed for equality. The issue on nuclear power is an enlighting example for that.

In our unit we try to fight resignation because of powerlessness by getting the students to participate in at least three areas. First, they are supported in setting their priorities for learning in selecting areas of emphasis, and in following their interests. Second, the unit is organized to permit students to plan their whole teaching-learning process together with their teachers. Third, the work in the classroom is directed toward public presentation and discussion of the learning results (e.g. panel, info-booth, exhibition).

Summary
The presented approach to physics education, developed at the Institute of Science Education in Kiel (FRG), transposes the controversial issue on nuclear power as it is represented in the Fed. Rep. of Germany into curriculum materials. Care is taken to retain its structural and procedural characteristics and to prepare student to cope with the issue responsibly; i.e., they experience and examine its scope and relevance, increase awareness and information processing ability, study controversial values and interests and handle conflicts, and participate in matters of personal and public concern.

Footnotes

[1] W. Westphal, Physics curriculum work at IPN. Physics Education, (1977), pp. 32-37.

[2] H. Mikelskis, Social science as a part of physics education — The IPN Physics Curriculum, in: U. Ganiel (Ed.) PHYSICS-TEACHING. PROCEEDINGS OF THE GIREP CONFERENCE 1979, JERUSALEM (Philadelphia, 1980), pp. 19-28.

[3] H. Hartel, R. Lauterbach, IPN PHYSICS CURRICULUM — INTRODUCTING A NEW APPROACH TO PHYSICS TEACHING IN THE FEDERAL REPUBLIC OF GERMANY, (John Murray, London, in prep.).

[4] H. Midelskis, R. Lauterback, IPN CURRICULUM PHYSIK, ENERGIEVERSORGUNG DURCH KERNDRAFTWERKE (Klett, Stuttgart, 1980).

7.8

EXPERIMENTS IN THE TEACHING OF ENERGY IN THE ROMANIAN SECONDARY SCHOOL

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In the introduction is shown the structure of the system of teaching in Romania. In its frame are indicated the number of hours affected to the teaching of Physics in accordance with the contents of the physics curriculum in the secondary school.

Further on, we develop the themes referring to the teaching of energy in different years of study and we present the experiments which have to be performed within that theme. We make stand out the experiments within its theme indicated by: a) the school programe; b) the text — books of Physics.

We show what experiments were introduced in teaching taking into account the proper experience of teaching or using another bibliography.

Then we mention the equipment at the disposal of the schools: apparatus of Physics for pupils, films, slides and we indicate some examples referring to the way of handling them on experiments to check up the conservation of energy.

It is shown the part of these experiments and their influence in the success of teaching energy in the secondary school of Romania.

SESSION 8: CURRICULA — UNDERGRADUATE

8.1 INVITED

THE ENERGY AND ITS CARRIERS: A UNIFIED APPROACH TO THE PHYSICAL SCIENCES

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Abstract:
A modern physics curriculum, developed by G. Falk and F. Hermann, is presented, in which the concept of energy plays a central role. This new approach to physics is not simply an undated way of explaining things with traditional concepts but, rather, is based upon a restructuring of physics as a whole. Fortunately, this restructuring naturally leads to considerable unification throughout the sciences and, futhermore, is easy to elementarize.

The basic idea of our approach is that descriptions of most natural events can be reduced to statements about the flow of energy. Thus, physical problems conceptually reduce to problems of energy. Accordingly, the energy is treated as a primary and not a derived concept. This means that problems of energy are as immediately accessible to one's intuition as problems of motion are to a student of traditional physics.

Introduction
I would like to present the outlines of a new elementary physics course developed at our institute by G. Falk and F. Herrmann at the University of Karlsruhe, West Germany (1). The energy plays a central and decisive role from the very beginning of this course. Although this course has been devised for children, ages 10-12, it is not simply an ad hoc construction just to get a fast grip on the energy concept (and not much more). Rather, it is based on a conceptual restructuring of physics as a whole. In this restructuring, which has previously been developed by G. Falk (2, 3), certain variables — which we call "substance-like" — form the basic concepts. Amongst these variables, the energy is particularly important. Structuring physics in this way favors a description of nature which represents considerable unification of the rules and operations within many branches of physics, including chemistry as well. At the same time, this approach offers the advantage of being easy to elementarize.

The *basic idea* underlying the course is that the explanation of most natural events can be reduced to statements about the flow of energy. In order to understand, in simple terms, what this means, let us consider the concept of energy itself from an everyday point of view. Contrary to a wide spread opinion, energy is something that we "get" during a meal and that we "run out of" after too much physical exertion. Energy is what our electric meter at home measures, what we need to heat our houses, to run our cars and so on. Energy is something like money: we all know when we have got it or when we have lost it. This way of looking at the energy has nothing directly to do with the ususal way of defining the energy mechanically, say, in terms of force and displacement or mass and velocity. The energy itself is taken as a primary concept.

Considering these examples more closely, it is easy to recognize that, whenever energy flows, something else flows along with the energy: the electric meter at home measures the flow of energy which, from a layman's point of view, is brought from the power plant into our house by the electricity; the warm water circulating through the heating system of a building brngs the energy from the boiler in the basement into the radiators within each room; the gasoline in our car brings the energy from the gas tank to the motor; light brings the energy from the sun to a field and so on. Energy is something like money: monetary value is always carried by something else (a silver dollar, a poker chip, a bank check, etc.) In the same way, we can say that something else "carries" the energy in each of the examples above.

This way of looking at the world remains valid whenever energy flows from one location to another. In other words, energy is *always carried* by something else, even if this something else might not be as familiar as in the above examples. Thus, we have the following *simple rule* applicable to all natural events: "Energy is flowing whenever anything is happening and this energy is always carried by something else." This is a more complete way of expressing the idea stated above.

A nontrivial example that this "something else" is not always simple to recognize but is, nevertheless, physically real is the following. Everyone knows that energy is required to move a car. Also, everyone knows that the motor in the car provides this energy. However, it is actually the rear axle which drives the rear wheels of a car, pushing the car along. Thus, it is reasonable to ask just how it is that the rear axle gets its energy from the motor. If we look under the body of the car, we see that the rear axle is connected to the motor via a drive shaft. If the drive shaft is removed or cut in two, the motor might be running, but the car nevertheless stands still: The rear axle gets no energy. Thus, energy must flow through the drive shaft into the rear axle during the normal operation of an automobile. Our rule says that this energy must be carried by something else. What then, might the energy carrier be in this case? The first thing we may notice is that the energy flow through the drive shaft has something to do with the rotation of the drive shaft: the car stands still unless the drive shaft is rotating. Could the carrier be the rotation itself? No: energy is flowing from the motor to the rear axle, but rotation itself cannot flow. The energy carrier is something which we can not see and which a physicist calls "angular momentum."

A modern physics curriculum
I would now like to present the essential points of our two year physics course for beginners. These points serve to outline the structure of a school book entitled "The Energy Book" (4) which was developed at our institute and is used by the children in this course.

Energy carriers
At the very beginning, the concept of *energy and its carriers* is introduced by way of numerous examples taken from everyday life. For example, it might be pointed out that, in order to do anything, say, to travel somewhere, we always need one type or another of fuel: gasoline for a car, hay for a horse, etc. This shows that something is contained in all fuels, independent of their particular nature and, since we have to pay for all types of fuels, this something is valuable. We call this something *energy*. We say that energy is "carried" by the fuel. We call fuel an *energy carrier*. Our experience shows that it is impossible for anything to receive energy unless this energy is carried by an energy carrier.

Energy sources and energy receivers

Next, the concepts of *energy sources and energy receivers* are introduced. Consider the flow of energy along with some carrier. Tracing this flow backwards, we eventually reach a point where the carrier current begins. We call the device where this takes place an *energy source*. Similarly, following the flow forwards, we again eventually reach a point where the carrier current ends. We call the device where this takes place an *energy receiver*. Furthermore, each carrier requires a channel through which it can flow. For example, an automobile engine receives energy with the carrier gasoline. In this case, the gas tank is the energy source, the energy channel is the fuel line. An electric light bulb receives energy with the carrier electricity. The corresponding energy source might be a battery. The energy channel is a wire. It is easy to think of many more examples which show how energy flows between various energy sources and receivers. For example, light carries energy from the sun to the earth; food carries energy from an agricultural field to man; blood carries energy from the stomach (or intestines) to the muscles of a person; a bicycle chain carries the energy from a person riding a bicycle to the rear axle of the bike and so on. We see that a particular energy carrier is associated with each source-receiver pair.

It is immediately clear that the flow of energy along with some carrier between a source and a receiver always displays the same structure. This can be symbolically represented by an *energy-flow diagram*. This type of diagram has an important formal function in the course. It represents a graphical picture of the energy flow and, at the same time, serves as an introduction to something which eventually leads to calculation.

Return and nonreturn energy carriers

Upon a more careful examination of the function of energy carriers, there seems to be two different kinds: *return and nonreturn energy carriers*. Unless it is stored within the energy receiver, the energy carrier does not just disappear withing the receiver. Rather, the energy carrier unloads its energy within the energy receiver and then goes further, either to be simply "thrown away" like a nonreturn soda bottle or to be returned to the source like a "return for deposit" bottle. It is easy to find several examples of each kind of energy carrier. For example, the air which carries the energy between the energy source-receiver pair, compressor-jack hammer, is a nonreturn energy carrier. On the other hand, the water circulating between the boiler and radiator of a central heating system is a familiar example of a return energy carrier. Nonreturn energy carriers are connected by just one channel between the energy source and the energy receiver, return energy carriers by two channels. Thus, return energy carriers flow in a closed loop: from the energy source to the energy receiver, where they unload their energy and then, back again, to the energy source where they are reloaded with energy and so on.

The property that something be a return or a nonreturn energy carrier is nothing fundamental. Indeed, in many cases, this characteristic is nothing more than a practical distinction. There are energy carries which can occur just as well as either return or nonreturn carriers, depending upon the way we might regard them. One example of this is the energy source-receiver pair: compressor-jack hammer. Here, the energy carrier is the air. If the return path of the air is left open, the air apparently functions as a nonreturn energy carrier. On the other hand, if the air, after decompression through the jack hammer, were to be returned via an air hose to the air-inlet of the compressor, the air would then serve as a return energy carrier.

After discussing the concept of return and nonreturn energy carriers, it is advantageous to introduce the energy carrier electricity. Since all electrical cables consist of two wires, it is easy to recognize electricity as a return energy carrier. Thus, electricity is an especially well-suited example of an energy carrier which is not only an invisible but also an abstract "substance-like" quantity like the energy itself.

The angular momentum is yet another invisible, abstract substance-like quantity which also plays a very common and fundamental role in physics as an energy carrier.

The energy load of a carrier

Next, it is pointed out that *the same carrier can be loaded with more or with less energy*. For example, consider heating a room with a hot water radiator. The water entering the radiator is obviously at a higher temperature than the water leaving it. On the other hand, we know that a radiator transfers energy from the water entering the radiator to the energy carrier air. Thus, the water at the higher temperature carries more energy than the water at the lower temperature. If we now replace the radiator by a hydraulic motor (or a jack hammer), then a similar consideration shows that water (or air) under higher pressure carries more energy than water (or air) under lower pressure. This all shows that a given current of water (or air) is loaded with more energy, the higher temperature or the pressure of the water (or air) might be. Similarly, the electric potential (or electric tension) is a measure of how much energy the carrier electricity is loaded with. With regard to these examples, a physicist would say that the temperature, pressure or electrical potential are a measure of how much energy an entropy current, a molar current or a charge current, respectively, are loaded with. We will come back to this point later when we discuss the formal basis of this physics course.

There are two ways for a carrier current to deliver a certain amount of energy in a given time interval. Either the flow of the carrier can be larger and the energy load smaller or, vice versa, the flow of energy carrier can be smaller and this carrier can be loaded with more energy.

One can think of many other examples of this simple fact. Perhaps the most personal and direct is provided by the energy carrier that we call food. Food loaded with much energy like, say, cream, must be consummed in a considerably smaller current, i.e. amount per time, than food loaded with less energy like, say, milk.

Energy transceivers

The next important step is to show that the energy fed into an energy receiver can also go further, that is, that an energy receiver can also serve as an energy source for some other energy receiver and so on. Thus, not all devices are really just receivers or just sources of energy. Rather, most energy sources and receivers can function in both ways: each is an *energy transceiver*. Numerous examples can be given of energy transceivers which receive energy from one carrier and transfer in to another.

We can represent each energy transceiver as a single block with arrows entering and leaving each diagram. For example, consider a solar cell as an energy transceiver. Then, these arrows represent the energy flow into a solar cell along with the energy carrier light and out with the carrier electricity. An electric motor is also an energy transceiver. Energy flows in with the carrier electricity and out with the carrier angular momentum. A simple water pump represents yet a third example. Here, the energy flows in with the carrier angular momentum and out with the carrier water.

It is obvious that these individual diagrams can be put together, forming a chain. With a little fantasy, this could be easily turned into a game of "energy domino." The rules for putting the energy transceiver diagrams together are essentially the same as those for putting the dominoes together: the energy carriers must match.

Energy losses
So far, we have considered an energy transceiver as a device which transfers the energy arriving with one energy carrier to another carrier which, in turn, carries the energy away. Although this picture is an accurate description of the essential function of an energy transceiver, the real situation is somewhat more involved.

Having accepted the energy as a flowing "substance," one is naturally led to expect that energy is conserved. However, it is easily observed that an energy transceiver seemingly does not give away all the energy it receives (at least not with one and the same carrier). Thus, if we adhere to the principle of energy conservation, it seems natural to suspect that all of the energy does not leave an energy transceiver with only one carrier but, rather, that part of the energy must be carried away with a second energy carrier.

This "lost" part of the energy is usually given up to the environment and is called "heat." We call the outlet of an energy transceiver where this part of the energy leaves, a *cooling outlet.*
The radiator of a car is such a cooling outlet of the energy transceiver "motor" because, there, the motor gives up heat to the surrounding air. Another, structurally quite similar, example of a cooling outlet is the cooling tower of a power plant. The cooling outlet of many machines is simply there, where the machine has slits from which warm air emerges.

Consider describing an energy transceiver in the simplest diagrammatic way, i.e., by a diagram with only one inlet and one outlet. Then, for any machine represented by such a diagram, there is another machine represented by reversing all the arrows on the first diagram. A familiar example of such a pair of diagrams can be quickly sketched for an electric motor and a generator.
An energy transceiver diagram which takes what we call the cooling outlet into account expresses the following observed fact: if it is possible to build a machine described by some diagram, then it is not possible to build a machine which would be described by a diagram resulting from the first one by reversing *all* arrows.
In a more accurate description, therefore, a generator is not simply a machine which, in all respects, does just the opposite of an electric motor. Notice that the arrow associatd with the cooling outlet is not reversed.

It is interesting to point out that the same diagram logic applies to all natural objects. This means that most objects have a "cooling outlet." Thus, in addition to all kinds of machines, this is also true for objects in which chemical reactions take place, in particular, for all living creatures.

The property of a real energy transceiver, that its total reversal does not exist, expresses what is scientifically called the *irreversibility of real processes.*

Some Basic Ideas of a New Approach to Physics
Substance-like Physical Variables
Usually, when we recognize something in our everyday life to be an energy carrier, a set of values for many physical variables can be associated with this something. For example, the word "electricity" usually refers to the free electrons in a conductor. These electrons have mass, charge, momentum, angular momentum and so on. We can even speak about the number of moles of such electrons. The same holds true for any other physical object we might think of, such as the water flowing through a central heating system, the gasoline in the gas tank of a car, even the light from the sun and so on. As we know from thermodynamics, Hamiltonian mechanics and quantum mechanics, the state of an object (viewed as a physical system) can be characterized by specifying the values of many physical variables associated with the object.

On the other hand, it is useful to ask just how many of all the physical variables associated with an object are actually responsbile for the flow of energy along with the object. For example, in a central heating system, the flow of energy along with the water is predominantly associated with the flow of the entropy at one or another temperature and not with the flow of the number of moles or momentum and so on of the water. Considering all the other examples mentioned above and many more which we might think of leads us to the same conclusion: even though values for a number of physical variables can be associated with every object which flows along with the energy, nevertheless, it is usually true that only one of these variables is predominantly responsible for the flow of energy along with the object. This fortunate circumstance is just what enables us to present an intuitive feel for the nature of these physical variables from an elementary point of view and to a beginner in physics.

So, when speaking as a physicist, the "something else" which flows along with the energy is actually a single physical variable. Since such a variable can be considered to flow, it belongs to a special class of variables, each of which can be thought to represent some sort of substance. We call such variables *substance-like variables,* for short. In addition to the energy, itself, examples of these are the electric charge, the entropy, the molar portion, the momentum, angular momentum and so on.

Each substance-like variable exhibits three properties which are very easy to grasp intuitively, namely: (1) Each is *additive* in nature; (2) a *density* can be assigned to each; (3) A *current* can be associated with each, i.e. each can be thought to flow from one region of space to another. Thus, each substance-like variable can be thought to obey a continuity equation (with or without source terms). Although in tradiational physics, most of the substance-like variables are derived in terms of primary, kinematic concepts, we take the substance-like variables themselves to be primary variables, i.e. to be elementary variables not defined in terms of other, supposedly more fundamental concepts.

Energy is always carried by something
In view of the above comments, let us again recall the simple rule mentioned at the very beginning of this talk: Whenever anything is happening, energy is flowing along with another substance-like physical variable. Expressed this way, it is not difficult to recognize that this rule is related to the following statement already familiar to a physicist from thermodynamics, Hamiltonian mechanics and quantum mechanics: a physical system can be completely described with the help of the ("total") energy of the system when the ("total") energy, in turn, is expressed as a function of the other substance-like variables (and their currents). Obviously then, it is impossible for the energy of a system to change without a simultaneous change in at least one other substance-like variable (or a current).

This is a more formal way of introducing the idea mentioned at the beginning of this talk, namely, that explanations of all natural events can be reduced to statement about the flow of energy. The above statement actually finds its origins in the work of J.W. Gibbs, approximately 100 years ago. It finds its mathematical expression in the so-called Gibbs Fundamental Form of thermodynamics.

I would like to further substantiate this idea from the point of view of a physicist by considering a few experiments.

For example, during the discharging of a battery through a resistor, we notice that the flow I_E of energy into the resistor, i.e. the dissipation of energy within the resistor, occurs simultaneously with a flow I_Q of electric charge around a current loop. But, what is usually called the power P represents the rate at which energy is being dissipated in the resistor and, therefore, we can identify P with I_E. Furthermore, we know that the power is given by the potential difference V between the poles of the battery times the charge current I_Q. Thus, we can write $I_E = V \cdot I_Q$. Because of the simple proportionality between I_E and I_Q in the above equation, it is convenient to think of the energy as being "carried" by the charge.

Another example is provided by the conduction of heat from one system to another through, say, a copper rod. Assume that one system at, say, temperature T is completely isolated from its surroundings except for its connection via the copper rod to the other system at temperature $T' < T$. We know that the change of energy dE within either system is given by the temperature T of the system times the entropy change dS, i.e. dE=TdS, if no other changes in either system are allowed. On the other hand, since neither energy nor entropy can be destroyed, the energy and entrphy changes of say, the unprimed system, can only occur if energy and entropy flow out of the system and into its immediate neighborhood within the copper rod. Thus, if I_E *and* I_S represent the net flow of energy and entropy into the system, this means that $I_E = dE/dt$ and $I_S=dS/dt$. With a slight wave of hand, we can divide the equation dE=TdS by an infinitesimal time interval dt and, using the above relations, obtain $I_E=TI_S$. Of course, if we continue to follow the flow of entropy through the copper rod from the unprimed to the primed system, we must take into account the fact that entropy will be created along its way. In this case, the entrphy current must be adjusted to accomodate the entropy created (irreversibly) from one infinitesimal segment of the rod to the next. In any case, just as in the previous example, the simple proportionality between I_E and I_S allows us to speak of the energy as being "carried" by the entropy.

As a third example, we consider an elastic collision between, say, two balls. To approach this example, we first simplify the collision by assuming the two colliding balls to be perfectly rigid, with one initially at rest. Then, we can model the elasticity of the collision by assuming a spring attached to, say, the ball at rest. Initially, the momentum P of the ball at rest is zero. During the collision, however, this ball accelerates, i.e. the time-rate-of-change of its momentum is positive. x . In addition, we know that momentum is conserved, i.e. momentum can neither be created nor destroyed. Accordingly, during the collision process, momentum must be flowing out of the (decelerating) incident ball through the spring and into the ball initially at rest. Thus, if I_p represents the net low of momentum into an object, then we have $I_p=dp/dt$. On the other hand, we know from Newton's Second Law that the force F acting on a body is given by $F=dp/dt$. This means that *the force* F *acting on a body and the momentum flow* I_p *into a body are nothing more than two names for one and the same variable.* Notice that, from this point of view, the concept of action-at-a-distance becomes a logical impossibility: an interaction is interpreted as a momentum current.

In addition, we are all familiar with the equation $P=V.F$. Here P, the power, is the flow of energy into, say, a body moving with instantaneous velocity V under the influence of an external force F. On the other hand, in accordance with the notation introduced above, we may prefer to designate the flow of energy into a body with the symbol I_E. Then, because of the above identity $F=I_p$, we can immediately rewrite the power equation as $I_E=VI_p$. Once again, we can think of the energy as being "carried" by another substance-like variable. In this case, this variable is the momentum.

These examples serve to motivate the individual terms appearing in the following mathematical relation:

$$I_E=V_1 I_{Q1}+V_2 I_{Q2}+TI_S+VI_p+\mu I_N+++$$

A theorist familiar with thermodynamics can derive this same result from the Gibbs Fundamental Form mentioned earlier.

The other terms in this equation can be physically motivated similarly to the terms already discussed above. In the fifth term μ is the chemical potential of a physical system and I_n is the associated molar current. The point is that all of these terms already appear in your physics text at home. Traditionally, these terms are referred to as energy "forms." For example, the term TI_S might traditionally be referred to as energy flow in the form of "heat" energy. We prefer not to use this terminology, however, for the same reason that a traditional physicist does not refer to a current of protons and a current of electrons as the flow of charge in two different "forms." There is only one physical variable, charge. In the same way, there is only one physical variable, energy. Thus, we refer to the substance-like variables Q,S, P, N as "energy carriers" instead of energy forms.

We clearly see from the above equation that each intensive variable V, T, V_1 μ... may be regarded as a "load factor," expressing how much the respective Q,S,P,N current is loaded with energy. This supports our comments about the energy load of a carrier mentioned earlier in the context of our elementary physics course.

The above equation can be read as: "The flow of energy is always accompanied by the flow of something else (another substance-like variable) which carries the energy."

This equation is the cornerstone of our approach to the sciences.

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8.2

CURRICULUM OF A THREE YEAR TECHNOLOGY PROGRAM IN ENERGY CONVERSION

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Abstract
A three year technology program in Energy Conversion is presented starting from its conception to implementation. In the first two years the emphasis is on general engineering with particular inclination towards alternative energy. In the third year, the students specialize in one of the two options: Solar Energy and Biomass.

Introduction
The worldwide decrease in conventional energy supplies has made the term ENERGY a basic word in the vocabularies of most nations of the world. New definitions and derivations of physical concepts are being developed to demistify the concept of energy and bring it into focus of our fundamental thinking. Books about energy conversion principles, processes and systems are being written. In a recently published book on energy conversion[1] the author, A.W. Culp, points out that, basically, there are two general types of energy; transitional and stored, and that conversions of most forms of one type into the forms of the other type are possible. By looking at the six major groups of energy forms: mechanical, electrical, thermal, electromagnetic, chemical and nuclear, one can easily conclude that the nuclear and the chemical forms exist only as stored energy types. Electromagnetic energy, the only "pure" form (not involving matter), exists only as transtitional type. The mechanical, electrical and thermal energy forms, however, can exist either as stored or as transitional types. An Energy Conversion Technologist is familiar with these fundamental facts, and has expertise in most efficient conversion techniques. He has an educational and professional background in design, manufacture and application of energy measuring and conversion devices, systems and controls.

The Energy Context of Ontario
In "Energy Securities for the Eighties"[2] the Ontario Minister of Energy announced a plan to reduce the energy imports from 77 to 65% by 1995. Approximately 40% of the total increase in self-sufficiency will be achieved by renewable energy contribution; a great part will come from solar energy and almost twice as much from biomass. The remaining portion of increase will stem from nuclear energy.
In this context conservation has not been identified as a "resource," probably for the same reason that savings cannot be confused with basic income even though they can help make ends meet - for a while.

Energy Conversion Technology - Conceptualization
A training resulting in expertise of graduates to optimize the performance of a variety of energy conversion devices which act together as a system, inevitably implies maximum awareness of conservation. For this purpose a students of an energy conversion program must acquire an interdisciplinary "bird's eye" view.

In view of the Ontario energy context and other indicators of emerging need for energy conversion technologists a three year technology program in the field of alternative energy has been developed and approved by the provincial Ministry of Colleges and Universities to start in September 1981 at the George Brown College, Toronto, Ontario, Canada. A Working Group of eight representatives from business, industry and educational institutions, involved in alternative energy field, was formed to brainstorm on program objectives and content of the courses.

Throughout the process of development of the program to its implementation, through all approval steps by the existing hierarchy of administrative bodies, this what we deem sound prototype program in energy conversion yielded an additional bonus: a curriculum development model particularly suitable to the provincially controlled educational setting in Ontario.[3] This model is possibly applicable to a variety of societal settings in which a thorough input from many potentially important channels is a prerequisite for a general acceptance of a new proposal.

In the above flowchart of the development of the Energy Conversion Technology program proposal one can recognize two main decision situations: the College Education Committee's go - no go decision point, and that of the Ministry of Colleges and Universities. Both are preceded by detailed collection and compilation of pertinent components of what is to become a complete picture of a proposal; the broader the range of inputs, the better.

The implementation phase is one of the phases which determines the visible image that the program will receive: Advertising of the new program inevitably causes a change in the established image of the institution; new projects determine the developmental potential of the program and can open new funding avenues. The home-room laboratory is an integral part of the visible image.

Energy Conversion Technology - Curriculum
The Energy Conversion Technology has a strong emphasis on general engineering in the first two years, dealing with mechanical and electrical energy conversion as well as microcomputer and electronic control fundamentals.
In the Energy Conversion (specialty) discipline, the emphasis is on Solar Energy and Biomass with a slight bias towards thermal energy, however neglecting chemical energy conversion and some important direct energy conversion processes such as photovoltaic and thermoelectric conversion.

The third year is the year of specialization in either of the two presently available options, Solar Energy or Biomass. The students take on one project for the duration of two semesters and a second project in the same option in the last semester. They may work on their project either in the home-room laboratory or in a co-op type arrangement with one of the institutions represented on the ECT Advisory Committee.
In Solar Energy the two projects may cover topics in solar heating — active (air and liquid) and passive — concentrators, photovoltaics, storage and as additional option wind turbines.
In Biomass the four major areas of combustion, gasification, anaerobic digestion and cogeneration are complemented by fuel preparation, waste management and storage.

The general engineering and the energy conversion disciplines rely on the strong foundation of science and communication courses. The average number of periods per week is 28. Over 40% of the program content concentrates on the two presently available speciality options with general engineering and academic disciplines occupying slightly less than 30% each.
The program is being implemented as a co-operative effort of Architectural Technoloy, Electro-Mechanical, English and Liberal Studies, and Mathematics and Science divisions.

Employability of Energy Conversion Technology Graduates
In Summer 1980 the Research and Planning department of the George Brown College conducted a thorough market study in greater Toronto area to ascertain the employability of future graduates of the proposed program.[4] 426 questionaires were sent out, of which 305 were aimed at institutions involed in alternative energy related activities. The response in this group was over 25%.

Answering to the hard question: "Would you consider a graduate of the Energy Conversion Technology program for employment?," the response extrapolated over 305 institutions yielded 173 job openings.
Another interesting fact supporting the need of a college trained technologist in energy conversion is the composition of the educational background of the 1980 work force in the institutions receiving the questionaire: Almost 29% had bachelor's degree, 25% secondary school diploma, and only 5% a three year college diploma.

Conclusion
Concerned individuals and institutions planning to develop an energy related training program certainly want to insure that the program is locally suitable in addition to its being globally desirable. This can only be achieved by involving an appropriate number of experts in energy, education and socio-economics from the private and public sectors. Their input should be sought throughout the existence of the program, and augmented by the feedback from students and graduates.

The design of the program should be flexible enough to incorporate changes suggested by the total feedback, without major sacrifice of the strong basis of academic and general engineering technology fundamentals. Periodical reviews following a set series of evaluation methods should take place to insure the program's suitability to changing societal needs and to maintain a high level of competence of its graduates.

Acknowledgement
At this point, we would like to thank Dr. R.B. Gwilliam, Dean of Mathematics and Science, and Director of Research and Planning, for making it possible to bring our proposal to the implementation stage. His supportive attitude and good judgement carried an immense weight in the development of this program.

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8.3

A PARTICIPATORY APPROACH TO UNDERGRADUATE ENERGY EDUCATION: THE CASE OF CLARK UNIVERSITY

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Abstract
Despite its small size and status as a liberal arts institution primarily, Clark University of Worcester, Massachusetts has the distinction of being one of only a handful of educational establishments in the country to offer an undergraduate degree in the interdisciplinary field of Science, Technology, and Society (STS). Since its inception in 1973, moreover, the most prominent feature of the STS Program has been its energy studies curriculum. Beyond offering a variety of regular courses spanning both the technical and social aspects of energy problems, the Program emphasizes student involvement in "on-campus internships." One project with which numerous students have been closely connected is the Energy Self-Study, whose centerpiece has been a DOE-funded inquiry of the possibility (soon to be realized!) of employing grid-connected cogeneration to meet the University's future energy needs. Another significant project conducted in recent years has been the Energy Phone, a statewide information and referral service contracted by the Massachusetts Energy Office and staffed exclusively by students trained to answer a wide range of questions on energy efficiency in the home. This paper describes the nature and scope of student participation in these special projects and their value from an overall education standpoint.

Introduction
Since the establishment of the Program on Science, Technology and Society (STS) nine years ago, energy education at Clark University has included an approach at learning distinct from both regular courses and individual research efforts. The approach centers on the creation of what might be called "on-campus internships," special projects that involve highly practical but are carried out in close association with courses tailored to provide the theoretical underpinnings necessary for such work. In this manner we seek to realize the benefits of having students work in groups on "real world" problems concerning energy use, without failing — as so often happens with the typical extramural internship — to effectively integrate the experience with the established academic curriculum.

We would like today to describe our two largest and most successful examples of this approach: 1) the *Energy Self-Study*, in which students have assisted in the evaluation of numerous energy conservation measures including, particularly, grid-connected cogeneration (for which Clark has been designated a national demonstration site); and 2) the *Energy Phone*, a student-staffed information and referral service for Massachusetts residents with questions on any aspect of energy conservation and use of renewable resources in the home. The Energy Phone has been especially important to the educational program because of the large number of students involved and the links it has forged with the outside community.

First, however, we wish to say a few words about the STS Program at Clark and its energy curriculum as a whole. Briefly, STS was established in 1972 with the initial impetus coming from the Physics Department and with fiscal support for development supplied by the Alfred P. Sloan Foundation. The basic goal of the program is to produce individuals who ultimately will be able to deal with technical issues in their broader societal context. Thus, undergraduates majoring in STS are expected to acquire facility with quantitative information and methods as well as the ability to critically analyze and evaluate social processes. They are also required to participate in problem-oriented courses offered in three basic areas — energy, environmental studies, and control of technological hazards.

Clark faculty members who are involved in energy-related activities are listed in Table I, the courses they teach are shown in Table II, and their various research and other proejcts are given in Table III. Of particular interest here, by way of background, are the regular course offerings in energy listed in Table II. Of these, the first four are introductory level courses on energy technology, economics, and policy; the next three are intermediate level courses in policy and planning; and the last two are the "practicums" affiliated with the self-study/cogeneration and energy phone projects respectively. The normal program followed by a students with an interest in energy has been to take one or two of the introductory courses, and then to join one of the "internship" projects by taking STS 272 or 273 (while taking, perhaps, a concurrent intermediate level policy course). The more accomplished students, moreover, often go on to write honors theses on topics emerging from their project work.

Thus, the two special projects we are about to describe are quite central to our energy curriculum at Clark. They provide resources to enrich the introductory courses; they are integral to all intermediate and advanced programs of study in energy technology (and much of the work on policy and planning as well); and they lead to extensive "capstone" research on an individual basis. With this in mind, let us now turn to a closer look at each project.

The Energy Self-Study/Cogeneration Project

The Clark Energy Self-Study was first conceived by the Chairman of the STS Program, physics professor Chris Hohenemser. In the Spring of 1973 — prior to the oil embargo — four students enrolled in his Energy and Society course and were assigned to investigate trends in fuel consumption at Clark. From this work evolved, in the following year, the first of the honors theses to come out of the STS Program — an analysis by Kathleen Hurley which showed there were many opportunities for energy conservation in the University heating plant. By this time the sudden rise in energy prices made some sort of follow-up seem important, and so a new course — Special Problems in Alternative Energy Systems (STS 272) — was convened in the Spring of 1975. Also inaugurated at this time was a fruitful collaboration between the STS Program and representatives of the Clark Physical Plant Office.

With an initial enrollment of nine students, STS 272 generated a number of useful research papers. These were published in-house as the first issue of the Program's student journal, the *STS Review*. Clark faculty and students were already considering the feasibility of a cogeneration plant. At the time, however, they were envisioning a stand-alone system of "total energy plant" which would isolate Clark from the electric utility. In 1976 another honors thesis followed up on this idea, and led to a separate issue of the *STS Review*.

Soon thereafter, Clark faculty began discussions with the local power company (Massachusetts Electric) to evaluate the possibility of *grid-connected* cogeneration at the University. A grid-connected system offers a number of advantages over a total energy plant: the equipment can be used more effectively by letting the electric utility provide back up, and more energy can be saved because electricity not needed on site can be sold to the utility. In any event, having begun to study the idea the Clark team found itself in an excellent position to respond, later in 1976, to a Department of Energy request for proposals for a national demonstration of grid-connected cogeneration. Of the twenty-two proposals submitted by various "communities" (towns, shopping centers, hospital complexes, and unversities), only five — including Clark's — were accepted. There followed a year and a half of feasibility studies and preliminary design, and then — after a two-year hiatus while the University struggled to finance the plant — another six months of final engineering design. Overall funding for the project has totalled in excess of $360,000.

Now, we are pleased to report that construction is underway. With plant start-up expected near the beginning fo 1982, the Clark project will be the first of the three national demonstrations to become operational. The facility will consist of a single large dual-fuel (diesel) engine which will generate about 1800 KW. Heat will be recovered from the engine exhaust in the form of steam from the waste heat boiler, and from the jacket in the form of hot water. The total heat recovery will be about 6 million Btu/hour. We anticipate an annual fossil fuel saving, counting the reduction in oil burned by the electric utility, of approximately 7500 barrels of oil.

During this four-year period, students in STS 272 have worked in two areas: 1) collecting the energy use data needed for sizing the system and its components: and 2) collecting information and assisting with the preparation of applicants for environmental permits. When the plant is built, we anticipate additional support from the Department of Energy for monitoring efforts to document energy flows, the system's energy and economic savings, the link with the electric utility, and air quality impacts. A significant fraction of this work will be performed by students enrolled in future session of STS 272.

The work performed by STS 272 students has been a mix of field and laboratory measurements and practical calculations. Included among this work have been building surveys, measurements of condensate return to determine building energy use, heat flux measurements and calculation of building material properties, air infiltration measurements using tracer techniques, ambient noise monitoring, tracer studies of plume dispersal, and calculations using EPA plume models. Lectures and readings provide the theoretical background for these measuring techniques and calculations, as well as an introduction to the current literature on building energy use and cogeneration technology. Previous volumes of the *STS Review* have also proved valuable as references in the course.

The Energy Phone Project

The second "on-campus internship" the STS Program has made available to its students, the Energy Phone, was operated under a contract with the Massachusetts Executive Office of Energy Resources from September 1977 through December of 1980. The Energy Phone was staffed entirely by specially-trained upperclass students from both Clark and neighboring Worcester Polytechnic Institute (WPI), and consisted of four widely publicized toll-free lines open during normal business hours. During the 40-month period of operation of the project, these part time "operators" (who numbered overall in excess of 100) provided answers to over 100,000 questions from the public at large, and mailed out over 20,000 information packages.

Another important funcation of the Energy Phone was to serve as a general resource to the state energy office and the local community for the implementation of a variety of special programs. At the local level, Energy Phone personnel hosted several meetings, gave numerous presentations and seminars, and served on the City of Worcester's Energy Policy Committee. At the state level, the staff conducted a survey on insulation practices, coordinated a contractor certification exam, established a summer gasoline hotline, helped smooth the transition to a new lighting code, and served as a clearinghouse for information in connection with programs on bank loans, oil burner tuneups, and alternative energy grants. It can fairly be said, in fact, that the Energy Phone in many ways became the conernstone of the public education and information efforts of the Massachusetts Energy Office.

Aside from its obvious public service benefits, the Energy Phone also provided a practical experience of considerable educational value to the students who worked for it. This occurred in three basic ways. First, through continual reference to a 250-page manual of fact sheets developed with the help of the students, through regular follow-up research using the mini-library assembled on the premises, and through frequent personal contact with a network of energy conservation professionals in government and business, the operators acquired a solid working knowledge of a wide range of measures to increase residential energy efficiency. Second, through use of our extensive referral files and through participation in the special projects carried out by the Massachusetts Energy Office and other state agencies, the staff became familiar with the internal structure and workings of the energy-related bureaucracy and the details of its outreach programming. Third, through literally hundreds of hours of direct telephone contact with both individual callers and representatives of various organization, each student had a golden opportunity to improve on basic communication skills and, where ambiguous or sensitive or controversial issues were involved, to develop a capability for good judgment.

Such "on-the-job training," of course, is not uncommon in a conventional internship setting. What sets the Energy Phone project apart, however, was that a condition of employment for all students was that they enroll in a regular academic course on energy conservation in parallel with their first semester of work as an operator. This course, STS 273, was specifically designed to provide a broader conceptual framework for the practical elements the students encountered day-by-day on the job. For example, by studying the mathematics of heat loss calculations or cost-benefits analysis of alternative conservation investments, the staff gained perspective on the level of confidence to be placed in various "rules of thumb" used to estimate savings, which sometimes lead to grossly misleading results. At the same time, through exposure to recent journal literature they came to appreciate limitations in our current understanding of both technical *and* behavioral aspects of energy use in buildings. They also saw that what applied research is being done to improve the state-of-the-art in both respects.

Another noteworthy aspect of this course is that it required students to complete a series of carefully constructed problem sets featuring applications of a practical nature. One exercise required that the student discover the method used by the staff of *Consumer Reports* in constructing a table showing dollar-savings for different levels of insulation and different degree-day zones, and then use to develop a similar table for a climatic region not covered in the article. Another assignment was based on material presented in an industry report entitled *The Professional Serviceman's Guide to Oil Heat Savings*, and posed quantitative questions about the optimal design of a combustion chamber, the relationship between smoke production and the chemical composition of combustion gases, and the mathematical basis for curves depicting heating plant efficiency as a function of temperature and CO_2 measurements.

Another way the course incorporated a practical dimension was through selective use of guest speakers. These invited lecturers, experienced practitioners familiar with recent developments in their fields, were scheduled after a sequence of two or three sessions (and usually one problem set) in which the fundamentals of the subject at hand were covered by the course instructor. This method proved particularly useful, for instance, in the area of heating system technology where rapid advances are being made withr respect to energy efficient design and operation. Guests were also employed with good result to demonstrate the process of conducting a home energy audit. Here, an audit trainer from a major consulting firm in the region was brought in to first describe the methodology of auditing (and some of the inherent ambiguities therein), and then to carry out the procedure — with the class in attendance — at a faculty-owned house in the vicinity of the University. Subsequently, the students were given as an assignment the task of assimilating the data and of preparing their own detailed report to the homeowner. This exercise served as a fitting capstone for the semester's work, given the nature of the course as a "practicum" in home energy conservation.

Concluding Remarks

From the experiences recounted above, we feel that the STS Program has succeeded in bringing the "real world" onto the Clark campus, to the benefit not only of its students but to many others as well. Implementation of conservation measures identified in the self-study project, for example, has saved the University approximately 40% of its annual consumption of fuel and electricity, and the $2.7 million national demonstration cogeneration plant will help point the way for other communities to do the same. The information services provided by the Energy Phone, moreover, has been instrumental in facilitating and stimulating a good deal of energy conservation across the state of Massachusetts.

The educational value of the two projects can be measured in several ways, such as by the number of students participating (the cumulative enrollment for STS 272 and 273 stands at 93), or by the high quality of the work most have performed. But in our view, the most telling indicator of education merit lies in the fact that STS graduates — equipped with job experience and factual knowledge together with conceptual, problem-solving skills — have enjoyed considerable success in pursuing subsequent energy-related activities. Some have secured positions of responsibility in state and local energy agencies, doing work ranging from legislative and policy analysis, to program management, to hands-on demonstrations for low-income community groups. Others have entered industry as energy engineers, plant conservation managers, weatherization auditors and retrofitters, and even (in one case) a wind-mill manufacturer. And several have been admitted to top graduate schools to further their education in energy technology and policy. We also count as one of our satisfying accomplishments the fact that, among the staff members who had a semester or more experience at the Energy Phone, *half* (26) have become career members of the energy conservation establishment.

What can be said now, in closing, to other institutions seeking to incorporate this kind of practical training in its curriculum? Certainly we would recommend student involvement in an energy self-study, since any building complex offers numerous opportunities for sophisticated measurements and interpretation (not to mention significant financial rewards). At the same time, it is important to recognize that there is a limit to how many student projects can be supported this way; in our case, enrollment in STS 272 has averaged only about six per year. Thus, for an institution that seeks to provide on-campus internships for a large number of students, one or more public service programs (like the Energy Phone, with enrollments at 20 per year) would be necessary.

The chief obstacle to achieving this is funding, of course, a fact of which we are painfully aware in light of the recent termination of the Energy Phone due to state budgetary limitations. This has had an adverse impact on Clark's energy curriculum, one that the continuation of the self-study cannot be itself offset. So, with the resources and expertise we have accumulated to date, we are actively seeking new projects to take up the slack.

TABLE I: MEMBERS OF THE ENERGY STUDIES GROUP IN STS

John Davies, Associate Professor, Department of Physics

Dennis Ducsik, Assistant Professor and Associate Chairman, Science, Technology, and Society Program

Robert Goble, Research Associate Professor, Department of Physics and Science, Technology and Society Program

Christopher Hohenemser, Professor of Physics and Chairman, Science, Technology, and Society Program

Marcus Cleinerman, Research Associate, Center for Technology, Environment, and Development

Peter Magnante, Research Associate Professor, Department of Physics

Don Shakow, Assistant Professor, Department of Economics

Linda Warrick, Project Director, Massachusetts Energy Phone

TABLE II: ENERGY RELATED COURSES OFFERED BY STS

STS 130. Energy Sources and Systems (Davies)
STS 131. Solar Energy (Davies)
STS 132. Alternative Energy Systems Laboratory (Goble)
STS 155. Economics of Natural Resources/Environment (Shakow)
STS 178. Nuclear Power Policy Issues (Hohenemser)
STS 201. Energy Paths and Policies (Ducsik)
STS 231. Electricity Planning and Decision-Making (Ducsik, Shakow)
STS 272. Special Problems in Alternative Energy Resources (Goble)
STS 273. Practicum in Home Energy Conservation (Ducsik, Davies, Warrick, Goble, Magnante)

TABLE III: FACULTY RESEARCH AND OTHER PROJECTS IN ENERGY

Feasibility of installing a grid-connected cogeneration plant on the Clark Campus (Hohenemser, Goble, Gottlieb)

Possible energy savings in the Clark heating plant (Hohenemser, Goble)

Evaluation of heat pump performance and solar collectors in the Worcester climate (Davies)

Measurement of conductive heat loss and solar collector performance on an experimental model house (Gottlieb)

New materials for luminescent solar concentrators (Kleinerman)

Small-scale alcohol fuels production and training (Magnante)

A systems study of the fuel-wood cycle in Kenya (Shakow)

Factors affecting capital cost and performance of nuclear and coal power plants (Hohenemser, Goble, Shakow)

Load forecasting in the Pacific Northwest (Shakow)

Development of a generation expansion and production model for power supply system analysis (Shakow)

Development of a normative approach to electricity policy-making at the state level (Ducsik, Shakow)

Critical analysis of electric utility planning and governmental regulation from the environmental standpoint (Ducsik)

Case study of state electricity regulation in the Seabrook case (Ducsik)

Citizen participation in power plant siting (Ducsik)

Energy conservation activity among Massachusetts homeowners (Ducsik)

Operation of a telephone-based information and referral service on home energy conservation (Ducsik, Warrick)

8.4

ENERGY MANAGEMENT CURRICULA: WHAT SHOULD BE THEIR CONTENT?

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Abstract

The need for the efficient use of energy in various systems — residences, commercial and public buildings, industrial settings — has resulted in the formation of Energy Management Programs in various places. What should be the nature of such a program — in particular, what should the curriculum content be for such programs at the college/university level? This question will be addressed and a particular curriculum which is being implemented will be described.

Introduction

This paper contains a description of an Applied Physics - Energy Management concentration program at Providence College. It is part of an overall concentration plan being implemented at Providence College wherein a Physics, Mathematics, and Chemistry core curriculum provide the basis for four distinct concentration options, three of these in the Applied Physics areas (one of these being the Energy Management concentration) and the other in a combined Plan Engineering Program. It grew out of the belief that there is an important opportunity for a liberal arts college to become involved in energy management education.

Energy Management Program

An appropriate definition of energy management appeared in a paper by L. Heisenberg and C. Daspit, presented at the eighty-seventh annual conference of the American Society for Engineering Education. In this paper, energy management is described as "an interdisciplinary, problem-solving activity concerned with assessment and control of the economic, environmental, and societal effects of energy resource distribution, production, conversion, or end use." In this context, an energy management program is considered to be a course of study which addresses a broad range of energy management issues. As a liberal arts institution, Providence College views energy management in the broadest context of the issues involved.

Most of the programs with which we are familiar are not at the graduate level and are associated with the applied science, engineering, and business-management schools and departments. The kinds of skills required for a professional or managerial level position in energy management, though, are certainly within the capabilities of an undergraduate program.

The content of an energy managment curriculum, at least with respect to the courses specific to the concentration, should be determined by what one expects the graduates of the program to do, i.e., how they will be employed. Employment of program graduates is expected in federal, state, city government, regional planning agencies, architectural and engineering firms, consulting firms, energy industries, and in all institutions which must come to grip with energy budget allocations. Anticipating these areas as outlets for students, we believe that the program should be built upon basic science and quantitative problem solving skills. The Heisinberg-Daspit paper suggests five areas of inquiry: technology, resources, environment/health, economics/planning, and politics/policy. They point out the significance of two additional categories: systems-modeling and simulation and interdisciplinary/synthesizing courses. We believe that these two areas are very important since energy managment is by its very nature an interdisciplinary, complex, decision-making activity.

Learning objectives should be established in the following areas:

- General Energy Science and Technology
- Modeling and Simulation
- Resource Economics
- Econometrics
- Energy Audits and Analysis
- Energy Hardware Systems
- Energy Software Systems, including regulations, codes, standards
- Instrumentation, particularly monitoring and control functions
- Energy Production Systems
- Energy Conversion and Distribution Systems
- Mechanical and Electromechanical Devices and Systems
- Oral and Written Communication
- Problem Solving and Management Principles and Practices

Curriculum

The Energy Management Program concentration at Providence College consists of a ten-course, 38 credit college core, a nine-course, 31 credit Applied Physics core, and a thirteen-course, 39 credit energy management concentration. The Applied Physics core consists of two semesters of General Physics with lab, two semesters of General Chemistry (Inorganic and Qualitative Analysis) with lab, and Calculus through differential equations (four semesters).

The energy management concentration includes the following courses:

• Electronics and a microcomputer laboratory course	credits - 8
• Upper division microeconomics and econometrics	6
• Business communications, accounting, management	9
• Interdisciplinary problem solving	3
• Energy science and technology	3
• Energy production systems	3

• Energy auditing/analysis	4
• Energy hardware/devices	3
• Energy laboratory course	3
• Work-study research	3-6

A typical program of study by years and a description of some of the courses are given below.

First Year:

Development of Western Civilization
Social Science Elective*
Physics 101, General Physics
Math 131, Calculus & Analytical Geometry

Development of Western Civilization
Social Science Elective*
Physics 102, General Physics
Math 132, Calculus & Analytical Geometry

Second Year:

Development of Western Civilization
Math 223, Calculus & Analytical Geometry
Chemistry 121, Inorganic and Analy. Chem I
Computer Science 121, 122, 123
Intro. Computer Program'g System
Model'g, Numerical Methods

Development of Western Civilization
Math 304, Differential Equations
Chemistry 122, Inorganic and Analy. Chem II
Physics 202, Electronic Devices, Measurement
& Control

Third Year:

Religious Studies Elective
Computer Science 151
Business 105, Intro. Account'g Princip.
• Energy Science/Technology

Religious Studies Elective
• Interdisciplinary 303
Business 118, Principlies of Management
• Energy Production Systems

Fourth Year:

Philosophy Elective
Business 465, Communications
• Energy Audit/Analysis
Research or Elective

Philosophy Elective
Energy Hardware/Devices
• Energy Laboratory
• Research or Elective

* Economics suggested
• Interchanged every other year

303 SYSTEMS APPROACH TO COMPLEX PROBLEM SOLVING *1 semester, 3 credits*

Philosophy and techniques for defining problems, generating alternative solutions, and evaluating solutions for problems which require a multidisciplinary study will be discussed. Topics to be included: defining objectives, analysis of functions to be performed, enhancing creativity, the structure of systems, value systems, cost and effectiveness, project management.

ENERGY SCIENCE AND TECHNOLOGY *3 credits*

An overview of the history and of the fundamental concepts in the development of energy science and technology as it is known today. The laws of thermodynamics and heat transfer and applications of these laws are treated. Traditional and alternate energy sources including fossil technology, nuclear technology, solar, renewable, and future sources are discussed. Applications and uses of energy in the industrial, commercial, transporation and domestic sectors are considered. The environmental impact, economics, and politics of energy will also be studied.

ENERGY PRODUCTION SYSTEMS *3 credits*

This course discusses thermal systems design and the analysis of efficiency for energy production systems. Both centralized and decentralized sources are considered. Topics include electrical power production from coal and nuclear sources, nuclear reactor design, advanced coal and nuclear technologies. Central station electricity from renewable sources such as direct solar, solar, power satellites, wind and ocean based sources, and geothermal sources will also be considered. Solar heating technologies are outlined.

ENERGY AUDITING/ANALYSIS *4 credits*

This course presents a comprehensive approach for conducting billing and field audits for a variety of facilities. Topics will include billing audits, end use profiles, envelope losses, HVAC loads, electrical system analyses, energy costs, life cycle costing, and federal programs. The course includes the development and use of computer audit programs, case studies, and a hands-on field audit.

ENERGY HARDWARE AND DEVICES *3 credits*

This course provides an overview of energy systems in current use in commercial, institutional, residential and industrial buildings. The course focuses on operating principles, performance, and maintenance of such systems. Topics include heating plant systems, distribution systems, energy recovery, lighting systems, refrigeration and cooling, solar hardware, controls, service hot water, ventilation, and cogeneration systems.

ENERGY LABORATORY COURSE *3 credits*

This course provides a hands-on laboratory learning experience on building envelope system principlies and solar-renewables through the use of both laboratory and field measurement experiments and computer simulations. In addition, energy survey instrumentation and energy management devices are studied and hands-on experience with this instrumentation is gained.

8.5

THE ENERGY CURRICULUM AT RAMAPO COLLEGE

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Introduction

Ramapo College was founded 10 years ago as an interdisicplinary four-year liberal arts college in Northern New Jersey. With a full and part-time student population of 3,800 and 150 full-time faculty, its is one of nine state colleges in New Jersey. Faculty from many disciplines focus on particular areas of study which are organized by schools rather than by disciplines or departments. One such school, The School of Environmental Studies, formed in 1975, consists of over a dozen faculty representing such diverse disciplines as ecology, physics, geology, geography, psychology, political science, planning, economics, sociology, philosophy and literature.

The School of Environmental Studies, with a student population of approximately 300 students, offers an interdisciplinary, often team-taught, core program of five courses totalling 20 credits which integrate scientific, social and policy areas. Advanced course work, consisting of a minimum of 30 credits, allows environmental studies majors to concentrate in one of four areas: energy, land/water, policy/planning, and social/cultural ecology. Completion of the fifty-credit major and seventy additional credits allowed the student to satisfy the requirements for a BA in Environmental Studies. This paper will consider only the curriculum and course work composing the upper level concentration in energy.[1]

Curriculum

A. Rationale

A few years ago, the U.S. became acutely aware that it was in the midst of an "energy crisis." While many Americans were initially convinced that this was merely a temporary situation contrived by oil corporations and politicians, they have subsequently become aware of the hard reality that there are serious limitations and constraints to our production and consumption of energy sources at ever-increasing rates. Moreover, an analysis of the situation provides dilemmas and trade-offs for our society as a whole and illustrates the complexity of our societal-energy relationships. It is now recognized that the energy debate is not merely one of competing technologies, but that a whole array of complicated social, political, economic and environmental questions are involved. The answers to these questions will allow us to make choices, and these will have profound impact on the future direction and quality of life of our society. The energy concentration seeks to provide the knowledge and skills which allow the student to explore the full dimensions of our energy choices from scientific, technical, social, political, economic and environmental viewpoints.

B. Program Requirements

The energy concentration requires a minimum of 30 credits at the upper level distributed according to the following categories:

1. Environmental Science - 12 credits at the 300 level and 4 credits and the 400 level.
2. Social Science - 4 credits at the 300 level.
3. Policy - 4 credits at the 300 level.
4. Fieldwork/Internship - 2 credits at the 300 level.
5. Senior Seminar - 4 credits.

Most students choose to pursue considerably more than the minimum credit requirement. The concentration is multi-disciplinary in scope and, together with the core requirements, insues that the student develops a wide range of integrated social science and policy knowledge with specific applications to energy issues, together with an in-depth theoretical and applied treatment of the scientific and technical aspects relating to energy production and consumption.

C. Curriculum Description

The upper level concentration in energy consists of some 21 courses offered over a two-year sequence, thereby allowing opportunities for both advanced and transfer students to make appropriate course selections. Many of the courses serve more than one concentration area within the school. For example, one course, *Energy and Social Change*, satisfies both Energy and Social/Cultural Ecology concentrations, while another, *Energy Politics*, satisfies both Energy and Policy/Planning concentrations. The present sequences of courses have evolved over the past few years and may be modified in the years ahead.

A basic assumption of the energy concentration is that a detailed understanding of the energy problem must be based on a solid scientific foundation. The environmental science component of the curriculum is currently taught primarily from the perspective of physics. Four sequenced physics courses specifically develop the physics of energy conversion together with detailed applications to energy technologies. One set of courses, *Energy, Power, and the Environment* and *Alternative Sources of Energy*, emphasizes the scientific basis and limiting factors in power production from all energy sources. The second set of courses, *Energy Efficient Solar Design* and *Alternate Energy System Design*, emphasizes the physical principles, engineering and design of small-scale renewable energy systems such as solar, wind, hydropower, wood, and methane.

Other courses expand upon the physical basis given in the four course sequence and provide more specialized treatment of related subject matter. *Meteorology and Climatology* elaborates on energy and radiative flows in the natural environment and incorporates data analysis and collection for renewable energy sources. *Radiation and Radioactivity in the Environment* emphasizes modern physics and includes detailed applications to fission and fusion power. *Computer Modeling in the Environmental Sciences* covers mathematical analysis, computer programming and modeling techniques with applications to energy-related problems. *Energy Conservation* analyses the potential for saving energy in the residential, commercial, industrial, and transportation sectors of our society by increasing efficiencies through both technological and lifestyle changes. *Passive Solar Design* explores the full range of materials, techniques and design options currently available or under development for passive solar applications. *Economic Minerals and Fossil Fuels* studies the fossil fuels, including their formation, distribution, supply, exploration and mining, from a geological basis.

There are four social science courses, taught from the perspective of sociology and psychology, which deal with the societal changes spurred by the energy problem. *Energy and Social Change* analyzes the growing debate on the social dimensions of the energy situation. *Energy, Technological Dependence and Lifestyle* explores the psychological dimensions of energy by considering attitudes, values, and behavior and their role in the choice, use and control of energy technology. *Alternate Technologies and Communities* considers the applicability of technologies such as solar and wind systems, methane digesters, aquaculture and bio-agricultural gardening in existing urban, suburban and rural communities and explores the relationship of these technologies to communal and cooperative lifestyles. *Technology, Values, and Society* looks at the development of the appropriate technology movement and the criteria which it uses to evaluate technological choices.

There are three energy-related policy courses taught from the perspectives of a geographer, a political scientist, and a planner. *Energy Resource Development* emphasizes the historical development of energy use, the geographical distribution of energy resources, the transportation of energy, and the effect of pricing and government regulation. *Energy Politics* considers the political and economic development of the energy industries, the role of government, market forces and newly formed interest groups. Analysis is focused on participants, their resources, strategies and goals. *Citizen Action and Advocacy* studies local and regional planning issues involving alternate technologies and decentralization, and the role of government, public interest groups, and citizens.

Practical experience and the development of construction skills in small-scale renewable energy systems is available through *Alternate Energy Workshop I and II,* offered sequentially every fall and spring semester. Some projects include: a 12 ft. by 24 ft. solar greenhouse, a 2000 watt wind generator system, a water pumping windmill, solar distillers, a passive solar classroom, and bio-agricultural experiments. Project work is performed at the Alternative Energy Center, a two acre site on campus which houses the above projects, and serves educational and research functions by demonstrating integrated alternate energy technologies for food production.[2] Advanced study is pursued at the center through independent study.

The internship program allows students to work off-campus one day a week for 4 credits. Placements are made which provide the energy-related experience in a variety of settings: industry, environmental organizations, architectural and engineering firms, community organizations and state and local agencies. Care is taken to match the student's background and desired experience to the placement position. Internships are carefully reviewed and those which prove educationally unprofitable are eliminated. The internship program has proved to be valuable in providing initial real world experience for students and in providing contacts for future job opportunities.

The Senior Seminar is designed to provide an integrating experience which builds upon the multi-disciplinary scientific, social and policy background of the student. Seminars are typically team-taught and serve more than one concentration area. Two seminars focus primarily on energy-related questions. A seminar entitled *Changing Patterns of Energy Use* emphasizes project work such as social impact assessment of energy alternatives, field work on energy attitudes and behavioral patterns, design of integrated energy systems, and the development of an energy plan for the college.[3] A seminar entitled *Technological Impact* uses a variety of technological assessment procedures, including methodologies for studying energy futures, to provide an interdisciplinary focus on the societal impacts of technology. Individual energy technologies are assessed by a team of students investigating the technological, social, political, economic, and environmental implications of various energy choices.

Summary and Conclusions

The energy concentration approaches the energy problem at the undergraduate level from an interdisciplinary perspective. Embedded in the context of an environmental studies curriculum, the concentration provides a generalist liberal arts education, together with specific energy-related knowledge and skills. Based on the experience of recent graduates, it appears to provide a wide spectrum of career and advanced educational opportunities as well as entry level positions in energy-related and other fields requiring scientific, technical, social, and policy knowledge and skills. And, regardless of career choice, the program provides the basis for informed and effective citizen involvement in the decision-making processes relating to energy choices.

References

[1] Further information on both the Environmental Studies and the energy curriculum may be obtained from the author at the following address: School of Enviornmental Studies, Ramapo College of New Jersey, 505 Ramapo Valley Road, Mahwah, New Jersey 07430.

[2] Further details on the Alternate Energy Center may be found in the following references:

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W. Makofske and J. Markstein, The Ramapo Alternate Energy Center: Ecological Design and Integration, *Proceedings of the Second National Conference on Energy-Conserving Solar-Heated Greenhouses*, Plymouth, Ma. April 6-8, 1979, pp. 283-288.

[3] See the abstract published in the proceedings of this conference by W. Makofske and M. Edelstein entitled "The Ramapo College Energy Assessment Study."

SESSION 9: CURRICULA — COMMUNITY COLLEGE

9.1

THE COMMUNITY COLLEGE CONCEPT IN INTERNATIONAL ENERGY EDUCATION

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Developing countries are experiencing a critical need for trained technicians. This is especially true in the field of energy — an area of new and rapidly-developing technology. An advisory panel for the United Nations Conference on New and Renewable Sources of Energy has stated, "One constraint for all technologies involved in developing new and renewable sources of energy is a lack of trained manpower." The panel recommended that the U.N. should strongly encourage and support the development of local technical training institutions and rural extension services in the field of biomass energy production, management, and conversion technologies.[1] The U.N. recommendation is equally applicable to training of technicians to work with conventional sources of energy.

An ideal vehicle for providing energy technician training is the community college. Community colleges in the United States have pioneered in training energy technicians.[2] James Mahoney, Director of the Energy Communication Center of the American Association of Community and Junior Colleges has stated

> ..... the variety and scope of community college energy activities are impressive. Their richness is evidence not only of their responsiveness to local conditions, but also of their interest in and capacity for contributing to the solution of significant national problems.[3]

The community colleges have added to their curricula such courses as coal mining technology, alcohol fuels production, energy conservation technology, as well as adding energy options to existing occupational training programs, such as those for heating/ventilating, air conditioning, and construction trades.[4]

The community college concept, as developed in the United States, emphasizes service to the community and responsibility for community development, as well as technical training. Important characteristics of the community college are

- low cost
- open access and equal opportunity
- emphasis on paraprofessional and technical training
- innovation
- student centeredness
- community based
- decentralized decision making[5]

In addition, the community college is an evolving institution. Clark Kerr views it as "the most protean, the most plastic, the most mobile of all the institutions of higher education."[6]

These characteristics make the community college an ideal setting for public involvement, dialogue, and education on energy issues. They also make the community college the appropriate educational setting for the development of new technical training curricula in the energy field.

Can this American experience in energy technician training through the community colleges be applied in developing countries? There is evidence of a worldwide movement toward the development of what Frederick Kintzer in his article, "World Adaptation of the Community College Concept," calls "short-cycle" educational institutions. These play a significant role in providing technical training in many nations, filling the gap between secondary and four-year-college education. Some differ greatly from the U.S. model, but all include some of the characteristics mentioned.[7] Thus, the potential for community college involvement in energy education and particularly, energy technician training, has international relevance.

Once the decision has been made to utilize community-based, short-cycle colleges for energy technician training, some crucial decision must be made. What types of training will be offered? What skills are most relevant to each country's particular energy situation? What types of education and training should remain at the four-year-university level, and which are most appropriate for the short-cycle college? What curricula should be developed? What will be the career patterns for the energy technicians graduating from the two-year institutions? How will these new technicians fit into the overall manpower structure of the country?

These questions make it evident that careful planning is needed to make energy technician training in the community college relevant to the overall energy and manpower needs of a developing nation. The energy technician curriculum must be developed within the context of a thoughtful and cohesive planning process. The purpose of a planning methodology used by the U.S. Department of Energy. Through this process, the community colleges in the United States played a key role in the development of federal energy research and development (R&D) priorities.

In this paper, we will describe the role of the community colleges in the federal decision-making process as it evolved through the interactive planning workshops, describe the Project Appraisal Methodology (PAM) developed by the Department of Energy (DOE), and explain the interactive planning process. Through the interactive planning workshops, the community colleges in the United States played a key role in the development of federal energy research and development (R&D) priorities.

The recommendation to embark on the interactive planning workshops came from the 1976 Energy Conservation Workshops for Community College Leaders sponsored by the Energy Research and Development Administration.[8] The principle objective of these workshops was to assess the role that community colleges might best perform in resolving the nation's energy problems. The participants concluded that the workshop concept itself was an excellent means of exchanging views and information, and that the community college would be an ideal host for any future workshops.

These workshops provided a means of ensuring regional participation in the federal government's energy planning. The president of the host community college was responsible for inviting a cross-section of community leaders who represented a wide range of skills and perspectives: local and state government officials, environmentalists, and other public interest representatives. The participants reviewed the plans and programs of the division and commented on the individual technologies and analytical methods used. The division then used the findings of the workshops to ensure that its programs reflected the broad needs of and concerns of the public. As a result, the public viewpoint regarding the ultimate acceptability of new energy technologies was integrated into the federal decision-making process.[9]

The Project Appraisal Methodology (PAM) described in this paper was developed by the Division of Power Systems in the U.S. Department of Energy to aid in the determination of R&D priorities. It was used for comparing a wide spectrum of applied energy R&D projects to determine which offered the greatest potential, and therefore, merited support by the division. The methodology basically involved the numerical scoring of projects for eight criteria: 1. energy savings; 2. technical risk; 3. cost; 4. commercial potential; 5. uniqueness; 6. resource availability; 7. environmental impact; and 8. legal, social, and institutional effects. For each project, criteria scores were weighted and summed to generate an overall score. The appraisal results were used to rank proposed R&D projects and to prepare budgets.[10]

The Project Appraisal Methodology (PAM) process was initiated by division project managers who prepared briefings on proposed projects. The data were then presented to appraisal panels composed of division staff, personnel from other divisions, planning analysts, an outside consultants. This process constituted the first appraisal. The second appraisal was performed by participants at the interactive planning workshops described above.

A critical component of the planning process called PAM is a feedback mechanism to ensure that the process is relevant, and to evaluate the methodology. The community-college-based interactive planning workshops provided a specific type of feedback mechanism, and consequently, played a key role in evaluating the Project Appraisal Methodology (PAM). Without an interactive planning component, without a feedback mechanism, PAM can lose its sense of relevance and fail to provide the optimum solution to problems it addresses.

Although the example cited here involves a U.S. government agency and American community colleges, the model could be adapted by governments of developing nations to set their priorities for energy technician training. The Project Appraisal Methodology (PAM) could be used by governments at any level to aid in planning and allocating resources, and in answering the following questions:

1. What are national energy objectives?
2. What are the energy manpower requirements for meeting those objectives?
3. Which of those manpower objectives can best be met by vocational secondary schools, by four-year universities, and which by short-cycle, community-based colleges?
4. Finally, what energy technician training curricula should be initiated in community colleges?

If PAM is applied to assist in making those critical decisions, it is likely that energy technician curricula will be designed that is relevant to the country's needs.

The interactive planning process can also be adapted to mesh with a developing country's decision-making structure. For example, an interactive planning workshop constituted to make recommendations about energy technician training in community colleges could be composed of the following: officials from the national ministries of labor, education, and planning; scientists, technicians, and engineers; academicians; representatives from energy and related industries; local and regional government officials; and community college administrators.

Community colleges around the world provide an ideal vehicle for the implementation of energy technician training to meet the manpower needs of developing countries. It is crucial that these training programs be initiated within the context of well conceived and cohesive energy and manpower planning processes. The Project Appraisal Methodology (PAM) developed by the U.S. Department of Energy is the ideal vehicle for the institutionalization of such a planning process. When used in conjunction with interactive planning workshops, PAM can be of enormous benefit in national development planning for energy manpower needs.

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9.2

A TWO YEAR DEGREE PROGRAM IN SOLAR ENERGY TECHNOLOGY

Dr. Francis Dunning

Mohawk Valley Community College is a comprehensive community college in central New York. It was established in 1946 and has a long history of technical education. When we designed the one year certificate program (Solar Energy Technology Certificate) and the two year degree program (Air Conditioning Technology — Solar Energy Technology option) we planned it around the existing strengths in the technology and physics departments. The certificate program has heating, heat pump, sheet metal fabrication and plumbing courses offered by the mechanical technology department, electricity and wiring courses offered by the electrical technology department, active and passive solar energy installation and alternate energy courses offered by the physics department. The degree program contains the courses included in the certificate program plus technical physics, mathematics and general education, drafting and photovoltaic solar energy and additional solar design courses.

When designing the program, the focus was the product (graduate) desired at the end of the two years. The product should have a firm foundation in the science of solar energy as well as the knowledge of the technology of solar energy. This balance required plumbing skills of a master plumber, the mechanical skills of a sheet metal worker, the physis and chemistry of absorbers, transfer fluids, metals as well as the engineering knowledge of wind loads, snow loads, impact forces, etc. The rudiments of these are necessary in any Solar Technology Program.

SOLAR ENERGY TECHNOLOGY
Certificate Program

Fall Semester			Spring Semester		
Code	*Course*	*Cr. Hrs.*	*Code*	*Course*	*Cr. Hrs.*
MA121	Fund of College Math 1	4	MT255	Heat Pumps	3
MT258	Hydronic Heating Systems	5	MT261	Warm Air Heating Systems	3
MT260	Sheet Metal Fabrication and Duct Design	3	ET110	Electricity and Wiring	4
ST111	Solar Energy 1	3	ST112	Solar Energy 2	3
			ST221	Passive Solar Energy	3
		15			16

The 31 credit hours specified above are minimum requirements for the Solar Energy Technology Certificate.

AIR CONDITIONING TECHNOLOGY
Solar Energy Technology Option
AAS Degree Program
(66 Academic Credit Hours)

Fall Semester			Spring Semester		
Code	*Course*	*Cr. Hrs.*	*Code*	*Course*	*Cr. Hrs.*
EN101	English 1	3	EN102	English 2	3
MA121	Fund of College Math 1	4	MA122	Fund of College Math 2	4
PH121	Technical Physics 1	4	PH122	Technical Physics 2	4
ST101	Alternate Energy	3	ST111	Solar Energy 1	3
MT127	Technical Drafting	3	CI115	Computer Science	3
	Physical Education	½		Physical Education	½
		17½			17½

Code	Course	Cr. Hrs.	Code	Course	Cr. Hrs.
BM101	Survey of Economics	3	ST221	Passive Solar Energy	3
ST112	Solar Energy 2	3	ST213	Solar Energy 3	3
ET234	Electrical Wiring & Codes 1	3	ST231	Solar Photovoltaic Cells	3
MT260	Sheetmetal Fab & Duct Design	3	MT255	Heat Pumps	3
MT258	Hydronic Heating Systems	5	MT261	Warm Air Heating Systems	3
	Physical Education	½		Physical Education	½
		17½			17½

Satisfactory completion of the twenty academic courses specified above is a minimum degree requirement for the Solar Energy Technology option.

9.3

WYOMING POSTSECONDARY ENERGY EDUCATION CONSORTIUM*

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Abstract
During 1980, a Postsecondary Energy Education Consortium was organized in Wyoming to assist in meeting the State's increasing needs for energy education. The Consortium involves Wyoming's seven community colleges and State University. The president of each of these institutions was contacted and all agreed that the Consortium would be beneficial for the following reasons: 1) to help plan for future vocational energy programs designed to aid in meeting energy development manpower needs in Wyoming; 2) to assist in designing courses to meet the needs of Wyoming's citizens who are interested in improving the efficiency of their own energy use; 3) to aid in preparing classes on general energy education and, 4) taking into consideration the energy education curricula development K-12, to help develop integrated postsecondary energy education curricula which can take students from high school energy classes into more advanced and technologically sophisticated energy education in college. A grant was obtained to help set up the Consortium and on 31 October 1980, an organizational meeting took place at Laramie County Community College in Cheyenne. At this meeting, it was decided that a needs assessment for energy education in Wyoming should be carried out and a grant has been obtained to initiate the assessment. Wyoming's Consortium has the potential of being a model for other states and countries.

* Supported in part by Wyoming 1202 Commission

Introduction
According to the 1980 census, Wyoming is the fourth fastest growing state in the U.S. behind Nevada, Arizona, and Florida. The 1980 census showed an increase in Wyoming's population of 43% over 1970. The main reason for this increase is energy development. In the mining of coal, oil, natural gas and uranium, Wyoming ranks among the top ten states. The "1980 Wyoming Mineral Yearbook"[1] lists the state's 1979 mineral valuation at $2,533,459,759. This is the largest single contribution to the valuation of the state. It is 53% of the state's valuation and is greater than the valuation of the entire state in 1977! Energy minerals account for approximately 95% of the state's mineral valuation. Because of the energy development associated with this evaluation, a bright economic future for Wyoming in an era of energy shortfall, seems assured. The energy development impact is being felt in all areas of Wyoming society: economic, political, social and educational.

The response of the Wyoming educational community to this energy development "boom" has been varied. At the postsecondary level, one response has been the organization of the Wyoming Postsecondary Energy Education Consortium. The Consortium, consisting of Wyoming's seven community colleges and one state university was organized in 1980: 1) to help plan for future vocational energy programs designed to aid in meeting energy development manpower needs in Wyoming; 2) to assist in designing courses to meet the needs of Wyoming citizens who are interested in improving the efficiency of their own energy use; 3) to aid in preparing classes on general energy education; and, 4) taking into consideration the energy education curricula development K-12 to help develop integrated postsecondary energy education curricula which can take students from high school energy classes into more advanced and technologically sophisticated energy education in college. These objectives are consistent with the statutory definition of a community college which is, "an institution which offers programs of academic work in the freshman and sophomore years of college, general vocational education in terminal programs and adult education services."[2] In 1945, legislation was enacted, "which permitted the organization of public two-year institutions."[3] Casper College in Casper, Wyoming was formed the same year. Northwest Community College in Powell was established in 1946. In 1948, Sheridan College in Sheridan and Eastern Wyoming College in Torrington were created. These four colleges were originally extension centers of the University of Wyoming; however, by 1956, the electorate of each of these districts had voted to establish independent community college districts. Western Wyoming College was established at Rock Springs in 1966 and Laramie County Community College in Cheyenne in 1968.[4]. At the end of fall semester 1980, the headcount enrollment figures varied from a high of 5,181 at Laramie County Community College to a low of 2,198 at Northwest Community College. The headcount for all seven community colleges totaled 25,096. The objectives of the University of Wyoming are: "to provide an efficient means of imparting to men and women, without regard to color, on equal terms, a liberal education, together with a thorough knowledge of the various branches connected with the scientific, industrial and professional pursuits."[5] The University was founded in Laramie in 1886.[6] The University had a final headcount enrollment of 9,014 for the fall semester 1980.

Review of Literature
Energy education is a nebulous field. However, there are some clearcut areas in which new classes might be initiated at the postsecondary level, especially in vocational programs. One source for information on energy education is "Energy and Education"[7], a newsletter published bi-monthly during the academic year by the National Science Teachers Association. It contains guest editorials, a calendar of energy education events and reviews of energy education literature. An early publication was the revised edition of "The Energy and

Environment Bibliography,"[8] published by the Friends of the Earth Foundation. A recent publication, with an extensive reference section, was "Energy Future."[9] Literature dealing with energy education in community colleges includes, "What Do Children, Alcohol and Windmills Have To Do With Community Colleges?" by Mr. Mahoney. It appeared in May 1980 issue of the American Association of Junior and Community Colleges (AACJC). Mr. Mahoney stated, "In fact, the variety and scope of community college energy activities are impressive. Their richness is evidence, not only of their responsiveness to local and national concerns, but also of their interest and capacity for contributing to the solutions of significant national problems." He summarized community college energy activities: "College activities fall in several domains: energy-related occupational course curricula, applied research, instititutional conservation, training for special community audiences and public information services."[10] The most recent publication in the area is "Energy Education Programs: Perspectives for Community, Junior and Technical Colleges,"[11] by Ms. Settlemire. This publication was sponsored by the AACJC and funded by the U.S. Department of Energy. It deals with: history of energy use in the U.S.; energy legislation; energy manpower projections; the role of community, junior and technical colleges in energy education; program components and program funding. Other publications used by Wyoming Community Colleges in energy classes include: "Energy and the Way We Live,"[12] a reader/study guide and National Geographic's, "Energy: A Special Report in the Public Interest."[13]

Discussion

The Consortium idea was born in 1977 at a meeting in Casper of representatives of four of Wyoming's postsecondary schools. This meeting dealt with the impact of energy development and what effect it might have on postsecondary education. It was evident that because of energy development, postsecondary institutions in Wyoming were going to be called upon to play an increasing role in energy education.

The first major energy education and energy conservation program influencing postsecondary education in Wyoming came as a result of the Energy Policy Conservation Act passed by Congress in 1975. Its objectives was to save at least 5% of projected energy use in 1980. In Wyoming, this resulted in the establishment of the Wyoming Energy Conservation Office and the Governor's Advisory Committee on Energy Conservation. Bill Edwards served on this committee for four years and was chairman 1977-79. This committee reinforced the idea that postsecondary education needed to coordinate energy education activities. In 1977, Wyoming was selected as one of ten states to participate in a pilot project of the Energy Extension Service (EES), a U.S. Department of Energy program. EES was administered in Wyoming by the Engineering College at the University of Wyoming with satellite offices at each community college. The target audiences for this program were primarily small businessmen and residential homeowners. EES worked mainly through outreach to encourage energy efficiency. The Governor's Advisory Committee was selected as the advisory group for the EES pilot project to help prevent overlap in the federal energy programs. In 1978, Bill Edwards was appointed to the National Advisory Board of the Department of Energy, Energy Extension Service. This appointment was, in part, a result of the American Association of Junior and Community Colleges desire to be represented on the EES Board. Contact was also made with Mr. Jim Mahoney, AACJC Project Director of the Energy Communications Center. Mr. Mahoney explained that AACJC was sponsoring "Energy and the Way We Live: A Public Issues Forum," funded by the National Endowment for the Humanities, State Humanities Councils, U.S. Department of Energy and others. Wyoming Postsecondary Institutions participated in this nationwide program in the spring of 1980. Laramie County Community College was designated the coordinating school for the forums in Wyoming and distributed information and materials to other Wyoming postsecondary schools. State Humanities Council funds were obtained by several schools to aid in the Public Forum presentation in Wyoming. "Energy and the Way We Live" helped coordinate postsecondary energy education activities and acted as a stimulus for the development of the Consortium.

In the fall of 1980, funds were obtained to determine the feasibility of establishing the Consortium. The Wyoming 1202 Commission, a federally funded program designed to coordinate postsecondary planning, provided the funds. Bill Edwards was project director and has subsequently become the Consortium director. The funding began in the summer of 1980 and continued into the fall. Funds were granted for two purposes: first, for visits to each of Wyoming's Postsecondary Institutions to confer with staff interested in the consortium idea. The college presidents and staff were quite receptive to the consortium concept. The October meeting included representatives from seven of the eight institutions, plus participants from the Community College Commission, the Wyoming Energy Conservation Office and the Wyoming Energy Extension Service. At this meeting, each college representative gave a short report on energy education activities at his school. Also, at this meeting a presentation was made by Frank Galeotos, Director of Wyoming's Manpower Development Office, on a project designed to make predictions on energy industry manpower needs in Wyoming. Three decisions were made at this meeting: 1) A Wyoming Postsecondary Energy Education Consortium would be organized; 2) The first endeavor of the consortium would be to consider vocational energy education or manpower training in energy fields, and 3) Funds would be solicited to do a needs assessment of energy education at the Colleges. Sheridan College extended an invitation to hold the next consortium meeting in Sheridan, April 1981.

Funds were requested for a second time from the Wyoming 1202 Commission by Esther Smith, Assistant Director of the Consortium, and a representative of the University of Wyoming. The 1202 Commission granted these funds to: 1) cover the operating expenses of the consortium such as attendance at the Spring 1981 meeting; 2) to publish a newsletter, and 3) to do a needs assessment of energy education at the community colleges.

A Consortium newsletter was distributed in June to participating schools, government agencies such as the Department of Education, industrial associations and other interested parties. Questionnaires were completed by selected students at all the community colleges to assess their needs for energy education. The results of the assessment will be used to design or redesign energy activities at each school and will be part of a long-term plan for energy education in Wyoming.

The future of the Consortium rests largely with the desire of the administrators of the eight institutions involved. To help clarify the commitment involved in the Consortium, a letter of understanding giving the objectives of the Consortium, the obligations of the Consortium to the instititutions, and the obligations of the institutions to the Consortium is being developed which will be circulated among the schools with a request for a signature by the chief administrative officer.

The elements of the Consortium which seem important include a statewide, non-parochial, view of energy education by the community colleges and a clearer understanding of the different roles of the university and community colleges and policies which are consistent with these roles. It seems desirable that the Consortium would continue meeting at least twice a year; that the newsletter would continue; that the needs assessment project would continue and that a summer seminar on energy education for staff members of the participating insitutions would be conducted during the summer of 1982. The Wyoming Postsecondary Energy Education Consortium has the potential of being a model for other states and countries.

Literature References
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9.4

A MODEL CURRICULUM FORMAT AND PROGRAM FOR ENERGY EDUCATION

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Introduction
A model educational program was developed for the United States Environmental Protection Agency, the National Training and Operational Technology Center, and the New York State Department of Environmental Conservation to train professional and sub-professional people in the fields of water and wastewater.
This program is now being used widely and has proved extremely successful. It is my intent to present this curriculum as a model to serve as the framework for similar programs in the area of energy education. The curriculum has been designed so that the purpose, instructional objectives, conditions, acceptable performance levels, and course sequences are clearly defined. It describes in measurable terms the skills and knowledge to be learned and furnishes the student with an honest definition of what he must know to successfully complete the program. It also provides the opportunity to standardize the curriculum in different colleges and training institutions throughout the country. The design further provides the ability to extract objectives or parts of objectives, and recombine them to form workshops, short training institutes, seminars or diploma programs. These then can be used for retraining or additional training, both of which are extremely important to the continuing education of the technician. Because of the definitive format, courses within the program or each individual instructional objective can be easily evaluated.

Text
In 1968, the United States State Department notified foreign governmnets that American oil production would soon reach the limits of its capacity. The end of an era of cheap abundant oil was at hand and the United States was to become a major oil importer. In 1970, American domestic production peaked and began to decline while the demand and use of oil continued to surge. For six months, the Arab oil embargo of 1973-74 threatened to paralyze the United States, setting off the worst U.S. recession in forty years. Since 1973, the world market price for crude oil has soared to its present price range of $36-41 per barrel. It is estimated that by 1985, the price may exceed $80 per barrel.

The need for energy, this insatiable thirst, has left the United States vulnerable to the political instabilities of the primary petroleum-producing countries of the world. At the same time, it is becoming clear that if we are to sustain our life style, we must begin to provide our energy needs by using other energy resources which, in many cases, exist in abundance. The United States has the world's largest coal reserves; massive reserves of natural gas; is a major petroleum producer; contains more than a quarter of the world's uranium; and is drenched with sunlight (500 times more energy than we consume each year).

Nothing comes cheap, however. To use these resources will require new technologies and new approaches to conservation. This in turn, will necessitate a massive work force skilled in the, often times, simple techniques of conservation or the highly sophisticated technologies of new energy production.

Because of its timing, energy educators have a unique opportnity to take a crisis situation and turn it to our advantage. The preponderance of energy courses, curricula and programs are all starting off at approximately the same time. If, as in energy production, we are developing and using new technologies, then we should be certainly willing to use new educational technologies in our energy education programs. *There is no longer any excuse for bad education. We can not justify it, we can not affort it, and we have reached that point in time where we can avoid it.*

The evolution of the need for energy education is in many ways parallel to that of the water pollution abatement training programs which were developed for the United States Environmental Protection Agency in the 70's and which now continue successfully into the 80's. Energy and environment have a kinship which can not be denied as many of the unpleasant and in some cases, unacceptable side effects of alternate energy sources are environmental. Similarly, training programs have been developed in the field of water resources that have provided not only superior educational programs and opportunities for those in the environmental technology fields, but also serve as a blueprint for the development and conduction of similar educational systems in energy education.

The program which I am reporting on today is one of the most successful of these and has had major national and international impact in all aspects of environmental education.
This program, the Water Quality Monitoring Program at Ulster County Community College in Stone Ridge, New York, was supported by the United States Environmental Protection Agency and the New York State Department of Environmental Conservation to meet the work force needs of the Water Pollution Control Act Amendments of 1972. These amendments provided for the wastewater treatment facility construction funds and the National Pollutant Discharge Elimination permit system.

The initial intent of the Water Quality Monitoring Program was to develop a curriculum based on the behavioral objective format and objective mastery. This format included the:

1. Development of a curriculum in Water Pollution Control, leading to an Associate in Applied Science degree, in which the graduate is productive immediately upon employment.

2. Use of the format of behavioral objectives in which the curriculum has been designed so that the purpose, instructional objectives, conditions, acceptable performance level and course sequences are clearly defined.

3. Production of a curriculum which the learning objectives are independent units that can be isolated and sequenced to provide a variety of instructional (critical) pathways for training personnel to do specific tasks. These pathways are used to provide a host of workshops and training programs of varying lengths and types. These programs have been used in continuing education for retraining or additional training of water quality personnel.

4. Design of a curriculum format from which a system of modules can be produced, thereby allowing the instructor to develop, evaluate, and use a variety of instructional strategies for any given course or objective. Additionally, when the "critical pathways" are identified and approved, appropriate instructional materials (workbooks, audio-visual materials, simulations, etc.) can be produced and made available. These pathways then can be utilized with a minimal amount of participation by instructional or supervising staff.

In 1978, the Water Quality staff at Ulster, successfully completed this project with the publication of four volumes. These publications are:

1. "A Two-Year Water Quality Monitoring Curriculum"[1]
2. "Learners Guide to Water Quality Monitoring"[2]
3. "Nutrients; Learning Guide for A Critical Path in Water Quality Monitoring"[3]
4. "Indicator Organisms; Learners Guide for a Critical Path in Water Quality Monitoring"[4]

In 1975, a prototype demonstration training program based on the Water Quality Monitoring curriculum was initiated. This program is rigorous, based on chemistry, analytical techniques, engineering principles, mathematics, communcation skills and humanities. Part of the measure of the success of the program is an attrition rate over the past five years of less then 15%, and a strong employment and transfer record. The behavioral objective format of this curriculum offers instructors and curriculum developers the flexibility to develop a multitude of pathways to meet varying or changing educational needs that can not be developed using the classical course description approach. These pathways enable students to enter and proceed through the curriculum from different entry points or to obtain partial skills which may not lead to a degree, but may make the individual employable or more useful in his occupation.

Further, because each objective stands as an independent unit, the objectives can be isolated and resequenced to provide a variety of instructional (*critical*) pathways for training technicians to do specific tasks. In energy, they could easily be the objectives necessary to obtain the skills for energy auditing, solar panel construction, or the theories of thermodynamics.

An example of an essential environmental objective would be:

OBJECTIVE
Describe and perform aseptically the listed techniques using the proper safety precautions:

a. Serial dilution
b. Pouring agar plates
c. Streaking Agar slants and plates
d. Making total counts
e. Aseptic transfers with loop
f. Preparing culture media
g. Counting colonies.

Each technique must be performed successfully and free of outside contamination 90% of the time.
One that relates to energy might be:
OBJECTIVE
Describe the effect of each of the following upon the rate of a given reaction, including the role of activation energy:

a. Temperature
b. Bond energy of reactants and products
c. Entropy change
d. Concentration of reactants
e. Catalysts

Discussion must include the relationships between:
a. Temperature, kinetic energy of molecules, bond strength, and activation energy.
b. The molecular geometry, the favorable arrangement of molecules for reaction, entropy, and reaction rate.
c. Concentration and the probability for a favorable collision in terms of energy and structure.
d. Catalysts and activation energy.

The Water Quality Monitoring Program has been a unique and highly successful experiment in higher education. It was based on the concept that ideas, skills, and tasks can be identified and clearly noted; and that what is necessary to be learned, and what is expected to be learned, can clearly be defined. Further, this process can include the conditions under which this knowledge is to be learned as well as the level of learning which would be considered acceptable for each learning situation.

It has shown that, if students prior to entering the program and then again in the classroom are informed of everything that is expected of them, including the performance level that they must achieve, their opportunity for success is greatly enhanced. Further, upon graduation, because they have obtained the skills they set out to develop, they will be highly valuable in the marketplace or highly sought after for transfer into programs of higher education. The system benefits, because it can be:

1. Readily evaluated (through student achievement)
2. Easily upgraded as, new laws, skills and techniques come along.
3. Readily modified to meet changing conditions and challenges.

Summary

The Water Quality Monitoring system is designed, developed, and implemented is a system which, utilizing the concepts of instructional objectives, offers the student, faculty and institution: objectives which are clearly and specifically defined; instructional pathways for the continuing education of the technician; modular programs which can be easily identified and produced; and a curriculum in which the components or the total system can be readily evaluated. The system has been classroom tested over the past five years. It has been highly successful, beyond our expectations. The students are competent, experienced, resourceful, marketable, and perform admirably in their work positions.

As a prototype program, the Water Quality Monitoring curriculum, concept and mechanisms are readily exportable and can be used as a whole or in part in training programs or institutions across the United States.
Because energy education programs are starting now, all at relatively the same time, it would be appropriate to adopt the educational systems and mechanisms which have worked so well in the Water Quality Monitoring Program. It would in fact, be folly to ignore it. There is indeed a challenge in meeting the future energy needs of a world without petroleum. There is an equal challenge to provide the very best energy education systems and training programs to as many people as possible as we enter this exciting new era.

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[3] Glazer, R.B., Et al. "Nutrients; Learners Guide for a Critical Path in Water Quality Monitoring." United States Environmental Protection Agency, 1978.

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9.5

SELF-RELIANT HOUSE: A MULTI-DISCIPLINARY CURRICULUM PROJECT & COMMUNITY RESOURCE CENTER

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Abstract

Merritt College Self-Reliant House & Garden is a multi-disciplinary curriculum project that is challenging faculty and students in a broad array of "academic" and vocational departments to cooperate in a common venture — the construction, operation, and demonstration, to the campus and to the larger community, of a model system of "appropriate community technologies." It will take the form of an urban/suburban house and yard. It will feature numerous practical methods for achieving a more economically and ecologiclly sound lifestyle — methods for conserving energy and other resources, producing food, and utilizing local sources of energy. It will serve as a focus for: including content of energy and resource efficiency in a wide variety of existing courses in many departments; the creation of many new, specialized courses; a significant expansion of community outreach, emphasizing evening and Saturday workshops and short courses; and individual and group tours. Importantly and most uniquely this project is designed to present appropriate technology in a *physical style* that will appeal to the broad populace. It will also contain a library of A.T. information and a community resources file. Early community participation includes in-kind donations of most of the building materials and many essential services by local businesses.

The Merritt College Self-Reliant House & Garden project will be a permanent, evolving center of appropriate community technology — a real-life model house and garden that will feature:

- a largely "passive solar" house — in essence a collection of "retrofits" (features that can be added onto existing structures, demonstrating a wide variety of insulating, weatherizing, and other energy conservation methods;
- a "grey water" system for water conservation;
- vegetable gardens, fruit trees, and small livestock;
- compostng and other recycling methods;
- demonstration devices for using local, renewable sources of energy;
- a library of relevant books, periodicals, pamphlets, audio-visual materials, and a community resource file. This resource center for appropriate community technology is designed to serve both the College and the larger community:
- College departments/courses involved in construction, establishment, and/or operation of the project are: Carpentry, Home Economics, Ecology & Appropriate Technology, Economics, Horticulture, Real Estate, and Welding.

* Self-Reliant House will contain the office of the Appropriate Technology program. It will be open for classes and tours six days/week and evenings.
* At Self-Reliant House and in nearby classrooms, laboratories, and shops we will conduct a large variety of A.T. courses and workshops, varying in length from single Saturdays and evenings to entire semesters. We also expect a heavy schedule of school and other group tours, as well as having convenient hours open to the general public.

Design Criteria
In the design of Merritt College Self-Reliant House & Garden, the following principles have guided the choice of features, and their details, scale, and arrangement.

A. Features should be *adapted to* the CLIMATIC, GEOLOGIC, ECOLOGIC, SOCIOECONOMIC and HOUSING characteristics of the East San Francisco Bay Area:

* Climatic - Mild, Mediterranean climate, with cool summer nights, few freezing nights; occassional drought years.
* Geologic - Subject to extreme earthquake activity; extreme variation in soil types.
* Ecologic - In summer, high fire danger in areas adjacent to natural vegetation; variety of wildlife activity in hill areas.
* Socioeconomic - Highly diverse cultural, ethnic, and economic characteristics of residents.
* Housing - Great mix of types and ages, but due to degree to which the area is built up, very little *new* housing to be built in the near future.

B. Systems and components should be, as far as possible, of *durable, recycleable,* and *non-polluting* materials and construction.

C. Retrofitable - all — or nearly all — features should be "retrofitable" (able to be added on) to existing houses and apartments. Thus these features would be relevant for all — or nearly all — residents of our community.

D. All features should be relatively low cost, or have a relatively short "payback time."

E. Simplicity - The construction, installation, and operation of most of the add-on features should be within the capabilities of the average "do-it-yourselfer," including the Merritt College students who will do nearly all of the actual construction.

F. Features should be likely to be adopted for use by local residents.

G. Features should be arranged so that the major aspects of function and operation can be readily observed by visitors.

H. The major areas and features must be accessible to persons in wheelchairs.

I. If sufficient funds can be obtained, some more complex or expensive systems — with long payback periods, or complex operational procedures, AND of particular educational value — should be purchased or constructed. Examples: urban aquaculture (fish pond) system; wind-electric generator.

J. Last, but far from least, esthetic standards of design and maintenance should satisfy the great majority of members of the community.

Major Design Features
A. ENERGY CONSERVATION
Insulation — R-30 ceilings; R-19 in walls; R-11 under floors. # See-thru panels to demonstrate: types of insulation materials; earthquake safety construction features. # Window and door weatherizing; windows and doors will be of different styles, to demonstrate the greatest variety of window treatments (double panes, inside and outside shutters, insulated curtains, etc.). # Small window areas on north and east sides. # Kitchen food cooler ("cool closet"), which enables use of smaller refrigerator. # Low-wattage refrigerator, cooking range, and lighting fixtures: careful design of lighting, with much use of "task lighting." # Insulation on water heater tanks and lines. # Ceiling-to-floor heat recirculator. # Air-to-air heat-exchange ventilator. # Room humidifier. # Temperature and humidity monitoring instruments.

B. "ALTERNATIVE" ENERGY SYSTEMS
South wall greenhouse/solarium solar collector, as well as roof skylight and clerestory windows, with water-filled drum "passive" storage, and movable, insulated shutters. # "Venetian-blind" type window solar collector. # Add-on rock-bin heat storage with ducts and blowers ("hybrid" system) *or* hydronic baseboard heaters hybridized with solar hot water system. # Solar hot water system ("active"). # Wood stove for supplemental space heating. # Fuel ethanol production system. # Solar photovoltaic emergency lighting system. # Wind-electric generator and storage (if wind data support it). # Solar clothes dryer.

C. WATER CONSERVATION
Kitchen recycling bins. # Hot-bin composting system. # Vermiculture (earthworm) system for recycling organic waste. # Use of the Merritt College Recycling Center (the oldest continuously operating in Oakland).

E. FOOD PRODUCTION, PRESERVATION, AND STORAGE
Raised-bed vegetable garden with wood-chip foot paths. # Indoor and outdoor planter boxes for vegetables. # "Foodscaped" front yard (low water and maintenance, with *edible* ornamental plants). # Fruit trees (dwarfs, for apartment roofs and balconies) in containers, and berry vines. # Beehive. # Solar greenhouse and cold frames for starting vegetables (greenhouse used as food dryer in summer and fall). # Breadbox solar oven (outdoor). # Rabbitry and chicken house. # Aquaculture (fish) system.

F. ECOLOGICAL PEST MANAGEMENT
Fly traps. # Mesh covering of garden beds to protect from birds, etc. # Crop rotation practices; experimentation with "companion planting." # Specially designed fencing to discourage deer, raccoons, etc.

G. EDUCATION
Library of relevant books, periodicals, pamphlets, and audio-visual materials. # Community Resource Directory file. # Display posters, models, see-thrus, etc.

H. OPERATIONAL FEATURES

Garden compost operation: use of garbage from the cafeteria kitchen and food classes, wood shavings from carpentry, and landscaping trimmings (this process has been in operation for two years). # Maximum use of the Merritt College Recycling Center. # Involvement of students from a wide variety of classes, plus College Work-Study students to perform routine operation and maintenance of the project.

Course offerings

What follows next is a listing of planned and proposed course offerings that support or are related to/spin off from the Self-Reliant House project. They represent offerings from six or seven departments, and some of them are cooperative efforts between two or more departments, "academic" and vocational.

Planned for the fall semester, 1981 (Sep. 9 - Jan. 28, 1982)
ALTERNATIVE ENERGY FOR THE HOME - What you can do to survive the energy crunch.
SOLAR ENERGY FOR THE HOME. Practical approaches for Bay Area residents.
ALTERNATIVE TECHNOLOGY LABORATORY. Practical, hands-on projects, including work on the Self-Reliant House project.
DO-IT-YOURSELF HOME REPAIRS. Learn preventive maintenance and how to make minor plumbing, electrical, and carpentry repairs.
EARTHQUAKE SAFETY FOR THE HOME. You can do much to save your home and life.
FRUIT AND NUT TREES FOR THE HOME. Selection, planting, and care.
ORGANIC VEGETABLE GROWING. Get your compost system and your garden going.
EDIBLE LANDSCAPING. Convert useless yard space into attractive, nutritious, water conserving edible landscaping.
ALCOHOL FUEL WORKSHOP. Learn to make your own. See operating equipment.
ALCOHOL PLANT CONSTRUCTION. Construction of small, wood, gas, or solar-fired alcohol production plant.
WIND ENERGY I. Utilization of wind energy. First course.
WIND ENERGY II. Second course. Make and test a small wind machine.
SOLAR/ENERGY-EFFICIENT HOME CONSTRUCTION. Construction of Self-Reliant House. Lectures on principles of design.
SOLAR HOT WATER WORKSHOP. Construct a professional-quality solar system for your home that will provide about 75% of your hot water needs. (This is the Suncor system developed at Arizona State University.)

Additional courses planned or proposed for fall, 1982:
EMERGENCY PREPAREDNESS FOR HOME AND APARTMENT
CRIME PREVENTION FOR HOME AND APARTMENT
FIRE PREVENTION FOR HOME AND APARTMENT
BEEKEEPING
ADOBE BRICKMAKING AND CONSTRUCTION
FOOD PRESERVATION AND STORAGE
GARDENING FOR THE HANDICAPPED
ORGANIZING A COMMUNITY GARDEN

Progress to date in developing the project

The most obvious progress so far is in the development of the curricular offerings listed above. Progress in developing the physical structures is mostly in the late planning and early to middle fundraising stages. We have done some site development: fencing, compost system, vegetable gardens, half built a free-standing solar greenhouse/food dryer. We have secured major donations from local business, most notably architectural and structural engineering services, excavation work, some concrete, roofing materials, a solar hot water system, some other building materials, and most notably, $10,000 in cash and services from the Pacific Gas & Electric Co., the local utility company. Local College and Central District support, in addition to salaries, consists of a small development grant of some $11,000, and several $1000 in contributions from the various departments, and several $1000 in "emergency" funds from the College President's office. We also have received a $5,000 grant from the California State Dept. of Food & Agriculture for experimentation with fuel alcohol production, using urban food wastes as feedstocks. Other government (federal) and private foundation grants are pending.

Finally, I would like to recap two of the special qualities of this project. The first of these is the emphasis on *design*: the *physical appearance* of the house and yard will, to my knowledge uniquely for a project of this sort, fall within *middle class standards*, in which the great majority of our people either live or aspire to (while we demonstrate the most ecnomical ways to achieve this style, while stressing ecologically sound function). The second is the involvement of diverse groups of people — particularly customarily "territorial" college departments, faculty and students, in a most rare sort of cooperation, along with business and community groups, and other citizens. We have pooled a rather vast array of talents, human energies, and material resources to produce a significant, visible, and lasting product (and most importantly, *process*) — a learning resource center for appropriate community tecnology. We expect this project to make a major contribution to the ability of our citizens to adapt to the profound changes in material resources that are sure to come in the years ahead.

SESSION 10: POSTGRADUATE AND CONTINUING EDUCATION PROGRAMS

10.1

ENERGY IN UK

SOME THOUGHTS ON THE NEED FOR AN ENERGY ENRICHED CURRICULUM

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The need

There can now be little doubt that the development of an 'energy aware' population should be an important aim of the educational system of every developed country in the world. Awareness of the needs and possibilities for the reduction of the rich countries high per capita use of the world's non-renewable energy resources must be developed through the formal curriculum of schools and colleges in order that our lifestyle and methods of production might be able to adapt to the inevitable changes in pattern of energy supply that will be forced upon us up to and beyond the year 2000,

"The Challenge to budge a lethargic, disbelieving society from a nation of profligate energy consumers toward one which is energy literate rests primarily with the educators ...."[1]

In the UK, which uniquely amongst the advanced industrial democracies, is self-sufficient in energy supplies, the task of curriculum renewal necessary to achieve this public energy awareness has not been undertaken in any systematic way - indeed it may be that the buffer of the UK's offshore oil and gas is a positive discouragement to the development of healthy energy attitudes and appropriate energy education provision. The Department of Energy based Advisory Council on Energy Conservation[2] reported in 1979 that "The prime need is to overcome the apathy that exists in the face of a problem of this nature - the failure to accept that there is a problem at all. This apathy is increased by the success we have had as a nation in exploiting North Sea oil ...."

Energy education in the UK

This same government-sponsored document recommended that significantly increased attention should be paid to energy issues by educators with an expanded Department of Energy education service supporting in-service teacher training and pursuing curriculum and exam syllabus reform. There has been a Department of Energy programme in operation for some time, but, underfunded and understaffed, it has so far had little substantial effect on educational practice. An enormous quantity of educational support material (though little of it is actual teaching/learning material!) has been produced by the education/public relations departments of the main energy agencies and oil companies[4], Whilst much of this material is informative and useful for the individual teacher having a specific interest in energy issues, the volume and inevitably partisan nature of such material can present a problem for the ordinary classroom teacher who recognizes energy's importance in his subject and who wants to introduce materials into his courses without spending lots of time and effort preparing them afresh. Such teachers need support, Frankly, UK performance in this area has been disappointing. There simply is no UK parallel to programmes like that of your National Science Teachers Association[5]. There are, it is true, a large number of small-scale initiatives taking place throughout the UK educational system but one feels that a measure of support for and coordination of these efforts is necessary if they are to have any real impact on UK curriculum. The UK education system is very decentralized, with decision-making on curriculum content residing very firmly at institutional level[6]. This results in a lack of uniformity which is particularly marked in the Further Education sector - it has considerable implications for curriculum innovation.

The UK education system

The UK education system can, in very simple outline, be seen as composed of three end-on components: the primary sector (ages 5-11), the secondary sector (ages 11-16) and the post-compulsory sector (age 16 plus). The post-compulsory sectory includes all the 'higher' education carried out in universities and polytechnics and that done in the 'sixth forms' of schools, 6th form colleges and in further education institutions. The further education institutions (which are the nearest thing in the UK to the USA's Community Colleges) are responsible for courses catering for students taking vocationally oriented or academic courses at any level up to and including post graduate work - the bulk of their work is however 'non-advanced' and FE's bread and butter is the provision of training and education for industry and commerce through an enormous range of part-time and full-time courses. The very complexity of the FE curriculum, which must be daunting indeed to anyone not involved in it, provides partial explanation for the almost complete lack of involvement by outside agencies in any coordinated attempt to stimulate the development of energy education in the FE sector.

Energy education initiatives in the FE sector

The development that is taking place is doing so as a result of initiatives in individual colleges and groups of colleges. Such an initiative has been taking place in my own college, Blackpool and Fylde College, and the other colleges participating in the activities of the Lancashire Energy Studies Development Group[7]. This group believes the FE sector has a key role in equipping UK citizens with the energy awareness demanded by present times[8].

"Many of the important small-scale decisions about energy use are taken by junior technical and supervising staff responsible for plant and vehicle maintenance, and the routine adjustment and control of domestic, commercial and industrial space and water heating systems. This workforce is still educated almost exclusively in further education institutions, where they need to learn the technical skills required for efficient energy use and to appreciate the importance of energy efficiency at a time of rapidly rising fuel costs and diminishing fossil fuel reserves. Unless this material is specifically written into further education syllabuses it is likely to be neglected or given only token support, particularly in view of present pressures on time and funding."

Some specific examples of energy-based courses introduced into these colleges may be cited:

1. Energy Resources GCE - a one year course involving some 200 hours study which covers in some depth the various aspects of energy supply, utilization and conservation. This course is offered as part of the academic curriculum and followed by relatively few students[9].

2. Energy Resources and their Conservation - a 15 hour module using structured learning materials included in the General and Communications programme for engineering students on Technician Education Council Certificate courses[10].

General studies is a compulsory feature of many curricula and one which thrives on the inclusion of topical and recognisably important themes such as the energy one. It is also one which can most benefit from the active involvement of personnel with a measure of technical expertise in the issues being considered. Although it is seen by many as low status activity, the 'servicing' of General Studies by teachers from a range of backgrounds relevant to the energy theme is probably one of the easiest ways to implement some energy teaching in the curriculum. It is significant that most of the active energy education projects in the UK have chosen the General Studies route. However, the introduction of specific energy courses and/or energy modules may meet resistance and so present only a partial solution in certain colleges.

Energy enrichment of the curriculum

As always, there are serious problems encountered by any proposal to amend curriculum content if that amendment demands any significant allocation of time, any funding and, above all, if it is perceived as threatening to any existing subject in the curriculum. In the absence of any objective reappraisal of the total curriculum that might give due weight to energy education, it is felt that an attempt to achieve an 'energy-enriched' curriculum[11] by sensitising teachers of various subjects to the relevance of energy work in their field is the best way forward. The development and dissemination of materials should demonstrate their opportunity to include energy work in their teaching courses without in any way prejudicing their ability to meet the demands of their examination syllabuses. Work presently being undertaken by the Lancashire group includes the preparation of a number of case study packages for use in a compulsory module[12] of the Business Education Council National Certificate course. The packages, including ones on energy use in a small business, the effect of rising fuel prices on a road haulage operation and one on the multinationals, are intended to take advantage of the widely recognized shortage of materials suitable for the teaching of the objective specified for this module. There are many other similar potential vehicles for the development of the 'energy-enriched' curriculum.

Teacher education

To encourage teachers from a wide variety of disciplines to 'energize' their teaching, attention must be paid to the provision of in-service seminars and courses. The current needs for energy education demand a far wider perspective than many teaching staff have been expected, or indeed encouraged, to have. Technical considerations cannot be viewed in isolation from the economic, social and political realities that condition what is practically possible in the real world. There is a real need to help teachers break out of the narrow disciplinary view of what they can and should teach which their education and training have conditioned them into accepting. Curriculum innovation resulting from the grass roots development that in-service courses can encourage is likely to survive. For, whilst national curriculum projects may have a role, it is widely recognized that the most lasting and cost effective innovations are those originated by the classroom practitioners themselves. Of course, if teacher 'enthusiasts'can be given a measure of backup support in the form of resources to develop teaching materials and the time and opportunity to attend meetings, still more effective implementation of new ideas if likely to take place.

Action not words

The acquisition of appropriate knowledge and healthy attitudes toward the need for rational energy use will not in itself lead to positive energy saving action on the part of students[13]. One way of encouraging positive action is surely to provide a module for it inside the educational institution itself. Educational buildings in the UK are significant consumers of costly energy for heating and lighting and are, on the whole, very inefficient users of this energy. It is believed[14] that self-help energy saving schemes in schools and colleges could reduce fuel consumption by some 10% quite easily. In addition to a large number of individual institutional attempts to operate such energy saving schemes, there have been some formal projects established[15] to examine ways of initiating and supporting such attempts based on student activity within the formal curriculum. Experience suggests that the main bars to success in maintaining such schemes are the lack of adequate instrumentation for extended monitoring of environmental parameters, and the lack of accessible and easily used computing facilities that enable real-life energy management tasks to be achieved by students from a range of backgrounds. The acquisition of microcomputer equipment dedicated to student use outside computer science courses provides the opportunity to considerably extend the possibilities for institutional energy management programme.

Micro-opportunities

Over the last two years, work has been done on adapting and extending the Schools Council Computers in the Curriculum materials on Home Heating[16]. Students following GCE Advanced Environmental Science courses have, on a trial basis, been using the computer programs to calculate expected heat losses from college buildings for subsequent comparison with energy use data supplied by County Hall. The experience so far has indicated the tremendous potential for further development of computer assisted learning based on the energy theme. Specifically, the data capture potential of the machines is seen as capable of considerable development. A current project in the College involves the design and construction of a portable battery-powered temperature monitoring device which can (without tying up any much-used micros in hard wired systems) store up to 1000 hourly temperature measurements for later debriefing into and manipulation in the memory of an Apple II Plus microcomputer. The important thing in curriculum terms is that this project is being carried out by students in one course (a 12 month full-time course training microelectronics technicians) to provide students in other courses with the hardward they need to do a realistic energy management task. It represents a fine example of the type of inter-faculty cooperation that can occur in the FE environment where a very wide range of staff expertise and student interest exists. The finished product from this project will hopefully be used to acquire temperature data in the college buildings - it is hoped to use future project work to adapt this development for the acquisition of data from solarimeters, windspeed and humidity sensors. Cooperative development of energy-based CAL packages is being planned - more sophisticated heat loss and heat gain models, economic aspects of fuel substitution in the domestic energy market and the human physiological factors influencing energy consumption in buildings are likely development areas. The present wave of 'micro-consciousness' being experienced in the UK presents an excellent opportunity for the dissemination of energy-based CAL packages that, because of their intrinsic interest in a number of disciplinary specialisms, might provide entry points to the teaching courses of those specialisms and so extend the 'energy enrichment' of the curriculum. Discussions have recently been taking place with representatives of British Petroleum and the British Gas Corporation to seek ways of implementing this idea.

Conclusion

As the recent Monte Carlo seminar showed[17], the needs for energy education development are now widely recognized on our side of the Atlantic. The onus is on professional educators to identify desirable and practicable ways of extending the coverage of energy issues in the curriculum in a manner that recognises the need for both their technical and attitudinal aspects to be considered. Efforts to 'energise' the curriculum must be realistic in recognising the legitimate demands of many other 'special needs' for time in the curriculum and must attempt to minimize resistance to their implementation by producing quality teaching/learning materials that teachers from a range of disciplines see as useful. Since energy conservation is so manifestly of practical value to all our students, everything possible should be done to encourage the realistic study of energy use in the home and in school/college buildings. Such study should take full advantage of the liberating power of microelectronics equipment wherever appropriate. There should be coordinating support for energy education initiatives on a larger scale than is presently available in the UK, but, in its absence, teachers and curriculum developers can still do a great deal to meet the needs through local and regional initiatives. In the UK, the FE sector has a crucial role in such development, responsible as it is for a uniquely wide spectrum of work with adults who are already responsible for the decisions that control our energy use. It is hoped that attendance at this Conference will allow us to benefit from your wider experience in the promotion of energy education and hence enable more speedy and effective development as a result.

Footnotes

1. BOTTINELLI, C.A. J. Energy Ed., 1,1 (1978)

2. Advisory Council on Energy Conservation, REPORT OF THE PUBLICITY & EDUCATION WORKING GROUP (HMSO London 1979), p.2.

3. IBID., p. 14

4. Mot notably British Petroleum, British Gas Corporation and the United Kingdom Atomic Energy Authority.

5. National Science Teachers Association, Project for an Energy Enriched Curriculum.

6. DES THE EDUCATIONAL SYSTEM OF ENGLAND & WALES (HMSO London 1972)

7. Lancashire Energy Studies Development Group is a teachers' curriculum development group, established in 1979 after an exploratory conference and now supported by Lancashire Education Committee.

8. HUME, D. Statement prepared in June 1981 for submission to the Department of Energy outlining the Lancashire Group's perception of the importance of the FE system's role.

9. Joint Matriculation Board REGULATIONS AND SYLLABUSES 1980 (Manchester 1979), pp. 453-461

10. TEC energy studies modules and teaching materials prepared by John Gray at Blackpool & Fylde College.

11. The term stolen from the NSTA project of the same name.

12. Business Education Council THE ORGANIZATION IN ITS ENVIRONMEN BEC NATIONAL CERTIFICATE COMMON CORE MODULE (BEC London 1979)

13. LUCAS, A.M. ENERGY ATTITUDE SAND ENVIRONMENTAL EDUCATION (Monte Carlo seminar Proceedings, In Print)

14. Times Educational Supplement (London 10 April 1979), p. 2

15. YANNAS, S. EDUCATION IN ENERGY MANAGEMENT (Architectural Association Graduate School, London 1980)

16. Schools Council COMPUTERS IN THE CURRICULUM: HOME HEATING (Arnold, London 1979)

17. A seminar held in Monte Carlo, Monaco on the theme 'Energy and Environmental Education in Europe' 25-31 March 1981 organised by ICASE.

10.2

CONTINUING EDUCATION FOR THE CONSULTING ENGINEER

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I. The problem

Today there is no more "routine engineering" for the Building Engineering Consultant. Every building project design is unique and its focus must be on energy conservation. Every energy improvement must be cost effective and requires a thorough assessment of its impact on our much abused environment.

Energy concerns have now grown beyond isolated issues for new and retrofitted structures. Economics, engineering, maintenance, operation, replacement, computer programming, and environmental impact should be included in the building design and energy analysis. "Hands On" knowledge concerning the total building construction project of site/building, mechanical/electrical systems and processes are an added responsibility of the Building Engineering Consultant.
Frank Zarb, former U.S. Head of the Department of Energy and now an energy consultant in industry, recently stated that *all* energy costs will triple in the next five years. Certainly, the need to provide energy efficient buildings and processes demands a new and positive response from the Building Engineering Consultant.

Yet, we find the following

1. Few consultants are up to date on the basic engineering skills essential to design energy efficient facilities.

2. Few are up to date on the new technologies available for energy balanced design.

3. Few are up to date on the environmental implications of the many available energy conservation measures.

4. Few are up to date on the new and necessary quality control programs required for the installation and operation of "Energy Balanced Buildings".

II. Role of the Building Consulting Engineer

In order to better understand updated educational programs that should be pursued for the various building engineering disciplines, a typical building construction project is broken out into its three major building components consisting of (1) Building and Site; (2) Mechanical and Electrical Systems; and (3) Process.

The Building and Site, the first component, are traditionally designed by Soils, Civil, and Structural Engineers. These engineers are involved in the determination of the proper bearing capacity of the soil or rock for support, as well as the design of the building structure. The Structural Engineer designs not only the foundations, but the floors, roofs, and column supports to provide sufficient strength for the building to withstand seismic, wind, live, and dead loading. In general, the Civil Engineer is involved with the site in the design of utilities, roads, parking, and circulation systems.

With today's high energy costs, a knowledge of the heating and cooling aspects of the building and the energy role of the building's envelope and structure are important to these professionals in order to help in the planning for reduced building energy consumption. The positioning of the building's mass is very important in maximizing useful stored energy in passive solar design. In just the past few years knowledge of how the sun can be utilized by the proper use of building materials and the building structure in passive energy design has taken a giant step forward. Designing the building itself as a solar collector and utilizing the mass of the building for storage requires current and specialized knowledge. This knowledge is needed by all members of the design team, which includes not only the Engineer but the other design professions as well, including the Architect and the Landscape Architect.

The Mechanical and Electrical systems, the second general component of the typical building construction project, comprise 50 percent of the total building capital cost. Mechanical, Electrical, and Energy Engineers are charged with the responsibility of designing energy efficient space conditioning and utility systems within the building. Economics can only be realized by an integration in their design of the site, building, mechanical and electrical systems, and processes for each particular project.
The veritable explosion of new energy "up front" systems such as the use of fluidized bed combustion of coal, the use of heat pumps, the design for active solar systems, and the utilization of more efficient methods of combustion of the traditional fuels of gas and oil require much more knowledge than ever before.
Few engineers are up to date on the use of Cogeneration, the simultaneous generation at the building site of steam for heating/cooling, and electricity to provide total industrial and institutional energy needs. Thus the client is denied the potential economics of cogeneration. The use of these systems will accelerate in the 1980's. The increased use of new and efficient lighting luminaries, variable air volume systems for comfort cooling, energy storage, and waste heat recovery systems should also see increased future application.

Process is the third component of the typical building construction project which is seeing a revolutionary change in design because of increased energy costs. In the manufacturing sector energy consumed for process usually far exceeds the energy used for the building operation. Knowledge of energy utilization and waste heat recovery in the specialized process areas has been lacking among the consulting engineers.
Processes in the environmental engineering field include industrial waste, water and air treatment. Laboratory analysis and control for the product manufactured and the impact of discharges to our air, water, and land need special attention for proper analysis.

In the three components noted above each typical building construction project may be in turn considered to have three phase periods. The first is the period in which the project is designed. The second is the period in which the building is constructed, and third is the post construction period or operation phase.
In each of these phase periods there is an increased need for engineering competance. In the Design Phase the consultant must be up to date on the many engineering alternatives available. Not knowing them could result in economic loss to the owner. The Consultant must be able to sort out the best construction and energy alternatives for life cycle comparisons.
In the Construction Phase the consultant must have a firsthand knowledge of the systems to be implemented as well as the procedures to insure a proper installation and operation for the owner. This should include the vast array of construction issues such as soil compaction, steel welding, and the operation of the mechancial/electrical systems.
In the post construction or Operation Phase the building consultant is involved in "in place" systems. This requires a "hands on" approach and knowledge to insure maximum system operating efficiencies. Needless to say, knowledge of controls and a thorough knowledge of system operation is a necessity.

III. Continuing education program - a solution

New building technologies, interdisciplinary knowledge and just plain human forgetfulness demand more than ever before a well planned

continuing education program for not only the Consulting Engineer and his staff, but the entire building design team.
The occasional attendance at seminars is only a small part of the answer. Each consulting engineering firm should work out a program with each of is members to include the basic engineering knowledge from a combination of the following:

1. Seminars
2. In-House Courses
3. Out of House Courses

Attendance at seminars for consultants and their staff can be helpful in upgrading their knowledge on specific engineering subjects. It is advantageous to assign specific engineering personnel to specific seminars. These individuals should then be expected to pass on the information to the other firm members in the form of "In House" seminars.
In addition to seminars, "In House Courses" can be given, preferably by personnel in the firm. Outside specialists should be called in to supplement the instruction.
The curricula for these courses should consist of not only basic engineering and new technologies of design, but the inspection and testing necessary for the satisfactory operation in the field. This includes, for example, a course in thermodynamics to the conducting of soil compaction tests.

Out of House courses are those which are best instructed by field experienced engineers. Specific educational programs can be set up by Technical Colleges and Universities to include courses of basic engineering and field inspection testing.
These courses are best planned in the three component categories of (1) Building and Site; (2) Mechanical and Electrical; and (3) Process.
It must be remembered that Continuing Education means just what it says. There is no end to it. For those who wish to progress there is no substitute.

The goals that should be set for each one should be as follows:

1. To provide an "in depth" review of engineering and economic principles.
2. To provide a background in new and old technologies which emphasize energy utilization and building construction.
3. To provide an "overview" background of the design and inspection required for all of the building components.
4. To provide an organized framework for each one to develop a specialized expertise in at least one area of practice.

IV. Summary

Because of our world-wide energy limitation, our present way of building and our traditional mechanical/electrical systems in many ways are obsolete. We are faced with the necessity to use new technologies, to change our way of design and our living habits in order that our retrofitted existing and new buildings will consume less of our expensive energy resources. Energy now constitutes about 20% of the Life Cycle Cost budgets of all buildings and the building construction industry is the largest in our country. The greatest barrier that we now face in the solving of our energy and construction cost problems is our lack of knowledge in the transition into Energy Balanced Design.

Successful energy engineering solutions require more education and an interdisciplinary approach. Successful solutions demand a thorough knowledge of the energy interaction occurring among the site, building, and mechanical/electrical systems. Design for energy efficiency must also be accompanied by a knowledge of economics and energy performance standards.

The medical and legal professional associations have already recognized their need and have mandated continuing education programs for its licensed members.

The Building Consulting Engineers who will henceforth survive in the marketplace will institute a program of continuing education for its membership.

SESSION 11: VOCATIONAL ENERGY EDUCATION

11.1

VOCATIONAL EDUCATION: A KEY TO SOLAR COMMERCIALIZATION*

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Introduction
Although the education and training programs of the Florida Solar Energy Center (FSEC) are directed at a variety of target groups, they all have the common objective of commercializing both active and passive solar devices as expeditiously as system acceptability and cost-effectiveness permit. The Center has identified vocational education as having a key role in solar commercialization. Consequently, a considerable amount of thought, effort and coordination have gone into developing a statewide program targeted at vocational educators. Principals involved in the development and implementation of the comprehensive program include the Division of Vocational Education (of the Florida Department of Education), local governments, district school boards, the solar industry, and the Florida Solar Energy Center.

The need for vocational education in solar energy
According to "Solar Energy Employment and Requirements 1978-1983, Summary and Highlights" (DOE/TIC-11154), prepared by Battelle Columbus Laboratories for the Department of Energy, about 22,500 persons in the United States were employed in solar-related activities in 1978 — a figure which is expected to triple by 1983. Approximately three-fourths were working primarily in solar water and space heating. Unskilled workers formed the largest occupational group in commercial activities; skilled workers made up the largest occupational group in installation; and engineers represented the largest occupational group overall. In seeking to identify unique aspects of solar jobs, Battelle found that only one of four employers thought they were substantially different from non-solar jobs. Where new skills were identified, special solar design, analysis and installation techniques were most frequently mentioned. Battelle estimated that there were about 2,000 active solar-related establishments and agencies in the national in 1978, 60 percent of them in private industry or business.

The Battelle results closely parallel those of a study conducted in 1979 by the Florida Solar Energy Center. FSEC's research was designed to project the solar industry's human resource needs, and it centered primarily on one area — solar water heating. Approximately 600 questionnaires were mailed to four target groups, including manufacturers of flat-plate collectors, distributors and installers of solar water heating equipment, manufacturers of solar energy system controls, and consulting engineers and architects.
FSEC's survey indicated that, although it found a relatively low level of activity in the solar industry, the 1980's will see a marked rise in demand for mechanics with solar experience, and that installation training is extremely important to the industry's success.

In September 1980, the Florida Solar Energy Center made a solar "Needs and Strategies" presentation to a special Florida Energy Advisory Council appointed by the Governor. The following recommendations are excerpted from that report:

1. Greatly expand the role of the community colleges and vocational centers in energy education, especially in solar installation training and low-energy building construction.
2. Establish pilot programs in selected counties to address the solar contractor license issue. Joint programs involving the use of community colleges/vocational centers to educate, train and test installers and inspectors are encouraged.
3. Expand monitoring of field systems throughout the state; expand site inspection of field systems.
4. Develop a comprehensive list of recommended practices which address solar collection, structural mounting, roof penetrations, control strategies, use of sensors, electrical connections, pumps, plumbing, freeze protection, heat exchange, auxiliary energy supply and storage. These practices would be largely based upon system test results.
5. Increase the level of awareness among the general public on low-energy strategies and do-it-yourself options. The community colleges and vocational centers are well suited to provide these services.

In December 1980, FSEC hosted a national conference on performance monitoring of solar domestic hot water systems. Results indicated that "... the performance of systems is less than what should be attainable...," and points to the need for more and better training, and more data collection.

Educating the educators
After examining industry needs, FSEC conducted a statewide Energy Awareness and Conservation Conference aimed at determining the needs of Florida's vocational education community. Several key areas were identified by the conference participants for cooperative efforts in commercializing solar energy.

FSEC currently offers quarterly short courses designed to teach participants how to install solar domestic water heaters and pool heaters. It would be very desirable to train vocational educators how to teach similar short courses. There is a present need for qualified, capable solar system installers. FSEC cannot alone reach the great number of people who are interested in learning about different types of solar systems, the relative merits of each, and the correct installation procedures.
FSEC is cooperating with the Division of Vocational Education to plan a series of week-long small group workshops that are regional in nature and designed to increase participants' knowledge and skills when working with solar. In addition, such workshops would enable participants to develop instructional materials for their own use. Local instructional materials can consider local climates as well as local codes and ordinances.

One of the major needs in commercializing solar energy in Florida is the establishment of a solar contractor license classification and the associated simplification of the building permiting process. The Construction Industry Licensing Board (CILB) of the Florida Department of Professional Regulation is currently considering the creation of a residential solar water heating contractor classification. Broward County (Ft. Lauderdale) has established a solar water heater installer classification and several other counties are considering various alternatives for licensing and certifying solar practitioners. If statewide solar licensing becomes a reality, or if more counties establish solar certification procedures, a greater need will develop for regional training in solar energy. In addition to the development of courses and course materials, examinations will have to be developed, updated and administered. FSEC is working with the Division of Vocational Education, the solar industry, the Department of Veteran and Community Affairs, and the Governor's Energy Office to establish meaningful and efficient programs related to the entire area of solar licensing, permitting, training, examination, and codes and standards enforcement. Programs in the community colleges and vocational-technical centers are well suited to these activities because of the expertise of their faculties, their orientation toward hardware and instrumentation, their regional distribution, the availability of technical students, and their association with building-related professionals.

There obviously exists a significant need for instructional materials relating to several disciplines emerging in the vocational-technical area. These materials should be developed in concert with the educators who will be using them as supplements to new courses, or as "plug-in" modules in programs designed to produce energy technicians as well as energy aware citizens. FSEC has the resources that enable the Division of Vocational Education to identify specific learning needs, the kinds of instructional materials desired, and can work closely with educators to develop and implement relevant teaching tools.

To meet the challenges of an impending solar transition, there must be a concerted effort to accelerate both the implementation of effective conservation techniques and the commercialization of renewable technologies. FSEC and the Florida vocational community hope to develop a statewide plan for the collection of meaningful data in the conservation and renewable resource areas. Only with such a data base can effective education programs be designed and prudent energy decisions made. The following represents a small sample of areas where significant needs for information and data exist:

1. Performance, reliability and durability data for low-cost, low-tech systems such as bread-box water heaters.
2. Side-by-side performance data for pumped versus thermosiphon versus bread-box solar water heaters for various microclimates throughout the state.
3. Freeze protection data for different freeze protection techniques.
4. Performance data for small wind energy conversion systems, especially near the coastline and in the Keys.
5. Storage subsystem heat loss data for various configurations at different locations throughout the state.
6. Comparative data on the effectiveness of various passive heat prevention and insulation strategies (e.g., vent-skin, exterior versus interior insulation, etc.)
7. Performance data on various passive heat gain techniques and their effect on heating and cooling loads.
8. Performance and durability data on various window films and heat retardants.
9. Performance data on various convection and ventilation measures and their effect on human comfort.
10. Comparative data on various active, passive and low-energy building designs.
11. Performance and reliability data on active colling and dehumidification systems (e.g., Rankine cycle, desiccants, etc.).

A model state solar program for vocational education

The main features of Florida's solar vocational education program are as follows:

1. The Florida Solar Energy Center, in cooperation with the Division of Vocational Education, acts as the technical resource center for the program. Instructional materials are based upon FSEC testing and research, task analyses, and needs assessments.
2. The FSEC, in cooperation with the solar industry, trains, on a regular basis, vocational educators in recommended sizing and installation practices for solar water and pool heating systems, and in recommended design and construction practices for passive and low-energy buildings. Consumer protection training is also provided.
3. Regional vocational institutions, using training techniques and materials from the Center, offer installation and design workshops throughout the state.
4. Vocational institutions offer continuing education programs on energy awareness and conservation, comparison shopping, and consumer protection.
5. The FSEC offers periodic workshops which provide updated information on the state-of-the-art.
6. The FSEC cooperates with the Division of Vocational Education in curriculum development and publications development, and provides information on energy conservation in physical plants.
7. Vocational institutions will hopefully cooperate by monitoring systems in their local areas.

Summary

In summary, Florida has developed a unique statewide educational network which involves a two-way flow of information and data between the Center and the vocational institutions. The capabilities of both are being enhanced, and the needs of the state are being served. Hopefully, information concerning Florida's success will be of use to others throughout the country and world.

11.2

VOCATIONAL EDUCATION AND THE SOLAR TRANSITION

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Introduction
If the decade of the '80's is to be characterized by a massive transition from conventional fuels to alternative energy sources, there will be a sizeable need to train and retrain workers during the inevitable transition to renewable resources. These persons will be critical to the rate and manner in which transition occurs. A strong thrust toward energy and conservation and using renewables offers the best hope for maintaining economic stability, improving environmental quality and increasing employment opportunities. The Harvard Business School Study, "Energy Futures," concludes that an enlightened program of conservation and continuing capital investments in solar technologies can significantly increase employment and help stabilize our inflationary economy.

Solar energy and jobs
As the nation takes steps to exploit alternative energy sources, it is important to recognize the potential shortage of technical and skilled workers as a possible barrier. Vocational educators are slowly establishing programs that will affect the supply of trained workers, but more and broader programs are needed. For example, the 1978 California study "Jobs from the Sun" concluded that feasible uses of solar for space and water heating could generate over 375,000 jobs during the '80's. This job potential could make the solar industry one of California's largest employers. Another study of "Solar Energy Employment and Requirements" predicted solar employment would increase from base year levels (1978) by 137 percent in 1981 and by 203 percent in 1983. Nearly 90 percent of the responding employers felt these jobs required special knowledge and skills and primary source of the skills should be formal training, yet a majority of the employees had not completed any training programs or courses in solar energy or energy conservation.

The demand for qualified mechanics and technicians is growing, and government, industry, and labor organizations foresee a potential shortage of skilled solar installers by 1985. The Florida Solar Energy Center (FSEC) estimates 15,000 DHW systems have been installed in Florida since 1972, 4,000 in 1978 alone. FSEC goals for solar installations, DHW and others, in Florida are 300,000 by 1985, and 2,000,000 by the year 2000.

The number of solar energy scientists, engineers, and technicians was projected by the Energy Research and Development Administration (now Department of Energy) to increase 40 percent over the decade. Many feel that figure is too conservative. A MITRE Corporation study predicted a billion-dollar applied solar energy business by the late 1980's. Most of the jobs created by industry growth will occur in the construction and conversion areas rather than in research.

Nationwide, 12 million new jobs will be needed over the next five years to regain 1973's peak employment percentages. Human resources studies show that the solar industry's job potential is two to eight times that of the coal and nuclear industries. Nuclear energy involves fewer tradespeople per professional scientist or technician than does solar energy. The ratio for nuclear is about two to one; for solar it is nine to one, and the rise in the number of solar practitioners has paralleled the dramatic increase in the number of researchers.

Yet, despite the predicted expansion of the solar field, a significant problem faces the industry today: without formal training in the principles of solar technology, persons employed in existing trades will not be able to make the transition from conventional heating and cooling applications to solar installations. Although some Florida counties require a licensed plumber to install solar systems, special training or experience in solar installations is not a condition of licensing. California offers a solar practitioner license to persons certified in the plumbing, swimming pool, and related trades, but not qualifying exam or prior solar experience is required for the license. This lack of regulation increases the chance of improper installation and system malfunction. In addition, the absence of building inspectors who are trained in solar applications, including their structural and design considerations, increases greatly the probability of system failure.

The Florida Solar Energy Center inspected hundreds of H.U.D. funded solar water heaters and concluded that poor installation practices and techniques are the primary cause of system failures. Problems discovered during the on-site inspections included improper roof penetrations, check valves installed backwards, poor plumbing connections and a host of problems associated with collector mounting and orientation.

A consumer protection study conducted by FSEC also concluded that the primary causes of solar system failure is poor installation, and the study identified effective installer training as a prerequisite for successful solar commercialization. Surveys indicating an overwhelming majority of satisfied consumers may be misleading, because consumer perceptions of complex system operation are somewhat unreliable. Consumer inability to detect malfunctions, compounded by unskilled installers, may threaten the "solar age." The importance of training, both for the installer and for the building inspector cannot be underestimated and consumer education is a logical extension. People have to know what to expect.

Flordia's needs assessment
FSEC and Florida's Division of Vocational Education conducted a needs assessment within the vocational community. Respondents included administrators and other key decision makers as well as district-level specialist and classroom teachers. Almost 300 persons took part in the assessment and while our findings are obviously Florida specific, we feel they do represent, to some degree, national needs.

Participants identified the need to designate area Vocational Education/Technical Centers as Energy Resource Centers offering materials, speakers, and resource people to districts as their first priority. Since several Florida Centers currently are offering energy-related coursework, this would be a low-cost recommendation to implement. Actual funding for the additional work of the Energy Resource Center would come from the Division of Vocational Education.

The second highest priority was to include energy education components in state-mandated In-service Master Plans for Teacher Education. This recommendation could be part of the assigned responsibility of the Energy Resource Centers and funded through existing mechanisms. The surprising support for additional teacher training indicated that many educators are not totally confident about their ability to integrate complex energy ideas into existing instructional strategies.

As one might expect, the third priority was to request funding for district level workshops to rewrite existing vocational curriculum guides to include energy concepts in existing subject matter materials.
Florida has an abundance of district level curriculum guides for most vocational disciplines. There also is a large national base of materials that needs to be adapted to Florida's unique needs. For example, "Providing for Energy Efficiency in Homes and Small Buildings," an industrial arts curriculum prepared by the American Association for Vocational Instructional Materials, lends itself to many construction trade practices in Florida. These materials would have a great deal more utility if they were linked to the Florida Model Energy Efficiency Code for buildings and passive design concepts for hot, humid climates. Funding a workshop to modify this curriculum would provide teachers in the building trades excellent resource materials taht are up-to-date and relevant.

A similar case can be made for modifying the "Energy Conservation in the Home" curriculum prepared by the College of Home Economics at the University of Tennessee and the "Home Economics" manual prepared by the Solar Energy Project in the New York Education Department at Albany. Both guides contain good material but they need adaptation to regional climates and educational environments.

FSEC is currently completing a task analysis for a solar water heater installer. The second phase of this project will convert the task analysis into instructional materials in the form of a V-TECS catalog. The careful systematic method in which the catalog is being developed should typify the developmental process for other energy education materials for vocational disciplines.

To ensure the orderly development of useful materials, a team approach using classroom teachers, instructional design specialists and experts on various aspects of energy conservation and alternative energy is highly recommended.

Conclusions and recommendations

Training for solar energy and conservation technicians and mechanics appears to be critical to the future success of the solar industry. Surveys of vocational centers and community colleges point out that graduates with several marketable skills are the easiest to place in meaningful jobs.

Consequently, it is not advisable to establish a large number of solar specialist training programs. We recommend the development of add-on solar and energy conservation skills through supplemental coursework and continuing education.

Several states have developed integrated vocational programs in response to this need. North Carolina's Climate Control Program is a high school skill development and training program that teaches the techniques of installation, service and maintenance of solar energy systems and methods of energy conservation in residential and commerical buildings.

Florida's St. Augustine Technical Center has developed an individualized, competency-based program designed to provide solar coursework options for students in plumbing, heating and air conditioning and other related building trades programs.

Vocational education can and must play an important role in the solar transition. Innovative teachers, creative administrators and supportive leadership at every educational level are critical to the success of this venture. Our experiences indicate jobs are waiting for qualified, skilled workers. Our nation's vocational centers can help meet workforce needs and guide us through the future solar transition.

11.3

CONSERVATION: THE OVERLOOKED COMPONENT OF ENERGY EDUCATION FOR VOCATIONAL EDUCATION STUDENTS*

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Abstract

The availability of energy resources has become a central concern in the U.S. today. The continuation of life, as we know it, of progress, growth, and a comfortable standard of living, depends on access to ever-increasing quantities of energy. The U.S. is currently facing the very real problems of limited and costly supplies of fossil fuels, possible energy-related environmental damage, and high costs for developing alternative energy sources.

Resolution of our energy problems lies in large part with energy conservation — in learning to manage and use our present resources more efficiently and productively. But a prerequisite to changing energy-using behaviors and attitudes is a national energy education program, designed to increase knowledge of the energy problem and of the available options and solutions.

Energy education is a critical area of concern for educators in the next decade. Energy conservation is one component of energy education, but one that is often overshadowed by analyses and descriptions of more dramatic events and issues of emerging technologies and energy production and development. Energy conservation is a topic of particular concern for vocational education whose function is to help prepare tomorrow's workers for the actual economic and employment conditions that will exist in this country. This paper describes the role of vocational education in promoting energy education, outlines a highly focused strategy to develop energy conservation instructional materials, and explores some of the barriers to the implementation and the development of effective conservation instruction.

The role of vocational education in conservation education

Energy education is not a new academic discipline. Rather, it is composite of traditional subjects, primarily in the physical and solid sciences, and more recent curricular topics such as environmental and consumer education. Energy education and energy conservation education are new only in the way the elements of these disciplines are interrelated, focused, or introduced into existing courses.

Schools teach with the intention of providing students with skills, attitudes, and knowledge functional to later success. When viewed in this manner, the critical role public schools play in giving legitimacy to categories and forms of knowledge becomes clear. The inclusion of conservation instruction in vocational programs is an indication of the legitimacy and growing importance of this issue. Vocational education is recognizing that new occupational skills and energy-related competencies will be required of people in existing as well as emerging trades and professions.

The function of vocational education defines three key areas of responsibility with regard to the energy conservation skills, attitudes, and competencies:

(1) Training students and future workers in necessary skills and practices related to developing energy conservation and efficient energy use and management strategies;

(2) Integrating or infusing energy conservation and management concepts, techniques, and skills into occupational programs that have potential for affecting the energy situation in some relevant way; and

(3) Increasing students' awareness and understanding of the seriousness of the energy situation, the importance of energy use and its relationship to their respective occupations, and the potential impact of personal actions.

Vocational educators are expressing interest in identifying and designing instructional materials that are compatible with vocational education's goal to provide job skills which meet labor market needs in response to contemporary societal problems and occupational needs. Vocational programs are currently being developed or adapted to train students to work in energy production industries, improve the quality of the environment, assist in urban rebuilding, develop better mass transportation systems, acquire skills that will enable them to find employment in industries developing alternative resources and technologies, and in general to teach people to be more effective in their use of energy. Materials that are appropriate for vocational education students and tailored to vocational education training programs are in demand.

For vocational education, the difficulties lie in organizing or identifying energy conservation information that is comprehensive, relevant, concise, current, and appropriate for use in vocational education programs. Additional difficulties lie in communicating this information to a widely diverse population of vocational education students and instructors.

Energy education: The need for instructional materials
A recent study conducted by the National Assessment of Educational Progress (NAEP)[1] found that while the young adults surveyed expressed deep concern about and awareness of the severity of the energy problem, they could not demonstrate a knowledge or understanding of basic energy facts or general issues and concepts necessary to make informed decisions. The results of the survey suggest that young adults are naively optimistic about potential solutions to the energy problems, and have a deep-rooted and unrealistic belief in the healing powers of technology. The authors report a positive relationship between the lack of knowledge about energy technology and expressed optimism in solving energy problems.

These facts are disturbing in and of themselves. But for professional educators, perhaps the most disturbing finding of the NAEP survey is that the respondents' naivete and lack of knowledge is not attributable to a lack of information. Young adults receive a high exposure to information about energy problems and issues. But most of this information comes from the popular press rather than from the schools.

However, the problem is not in the lack of eduational materials per se, but in the lack of *usable* instructional materials. When energy information is made available to the schools, the materials are rarely in a form appropriate for use by students. Typically the classroom materials used are isolated units of information that seldom constitute a consistent or intact curriculum.

Industries have taken active roles in producing materials for distribution to schools and industrial training programs. For example, Gulf, Chevron, Phillips, Amoco, and Exxon all offer energy-related educational teaching aids as part of their public relations programs. However, some of these materials have been criticized as one-sided and self-serving. In response to criticism about their aggressive propaganda tactics, company representatives explain their programs as public service efforts, developed in response to teachers' requests for current information.

In addition to the public relation materials, there is a vast array of literary analyses, fact sheets, informational manuals, and research reports on energy conservation programs and energy issues of production, supply, and demand (Hayes, 1976).[2] There are also numerous energy awareness materials that document historical, sociological, environmental, or scientific perspectives on the current energy situation. However, much of this material is of a highly technical and sophisticated nature, written from a biased perspective, and not appropriate for instructional purposes or amenable to adaptation for classroom use.

Effective energy education and energy conservation programs and curricula have been developed or implemented by a few local organizations — public schools, area vocational centers, regional occupational programs, community college districts, and various community agencies (e.g., National Science Teachers Association, 1975).[3] However, the appropriateness and use of these materials outside of the locale, timeframe, or specific context for which they were developed is often limited.

In addition, the lack of effective dissemination procedures is a common problem confronting curriculum developers. Another problem facing educators is the difficulty in keeping the factual content of the materials current and accurate when there are no funds or provision to update and revise the materials once the development has been completed.

The lack of accurate and up-to-date information underscores the need for unbiased instructional materials in energy conservation. But if the materials are to have direct potential for affecting the energy situation, they must be relevant and related to the experiences, training, and instruction received by students. They also must be in a format that can be used by teachers and can easily be integrated into existing programs. There is, therefore, a strong need for a consistent educational strategy to provide students with a knowledge base for understanding and evaluating energy issues, one that highlights the linking cause and effect relationships between behavior and outcomes.

Instructional design strategy implemented by the American Institutes for Research (AIR)
The American Institutes for Research has undertaken a highly focused curriculum development strategy to meet the need for occupation-specific instructional materials for use in vocational education programs. An underlying assumption of AIR's program is that studnets need to understand that their personal contributions are significant, and that the energy savings accomplished by each individual contribute to the national effort to conserve energy. Prior to any attempt to develop the educational materials, an instructional design strategy was implemented that included the following elements: literature search, identification of specific occupational and instructional areas for module development, and analysis of competency data. These activities are briefly described below.

Literature Search. The first step in this strategy involved identifying, collecting, and reviewing energy use and conservation materials. The literature search procedures included personal interviews with individuals involved in conservation efforts, computerized literature searches, reviews of energy-library holdings, and reviews of materials recommended by others. The identified materials were then evaluated as to their instructional appropriateness for use with vocational education students as well as their comprehensiveness in addressing both general conservation issues and on-the-job conservation practices. Based on the results of this systematic survey, the occupational areas in which conservation instructional materials were lacking, insufficient, or inappropriate were identified.

While conducting the literature search, a comprehensive list of energy conservation issues related to worker motivation was also compiled. The purpose of this effort was to establish a framework and instructional context for module development. The list identified effective practices and concepts for influencing worker motivation as well as conservation issues and practices most related to individual responsibility and control, individual benefits, and the collective value of individual performance.

Identification of Specific Occupational and Instructional Areas
The next step in the development process involved application of selection criteria for identifying the occupational areas and instructional programs in which energy conservation materials were most needed. Selection criteria included:

* relatively high student enrollment figures in the occupations and relted vocational programs
* high projected student enrollment (1980-1985) based on occupational outlook projections
* the lack of appropriate instructional or training materials (as indicated by the literature search)
* a relatively high estimated potential for energy conservation in the identified occupational area.

These criteria were used to establish a multi-dimensional definition of instructional and programmatic needs as determined by the current and projected programmatic size (student enrollment), and adequacy of instructional or training materials relative to the estimated amount of energy savings.

Analysis of Competency Data: On the basis of the literature search, a list of student competencies were developed to serve as guides for curriculum development. The student competencies were identified and analyzed in consideration of both the specific skill requirements for each of the identified occupations and the instructional goals and objectives. Vocational competencies were also examined with regard to their potential for incorporating conservation skill and practices. The final selection of occupational competencies defined the scope of module content as well as the instructional format, learning activities, test items, and related resource materials that were included in each module. A module format was designed that would mesh the instructional materials with ongoing educational activities, and would be compatible with adopted courses and vocational training programs.

The outcome of these efforts is the development of an interrelated instructional series designed specifically for use by vocational students and teachers. These instructional materials include:

* two introductory motivational modules,
* twenty-two occupation-specific energy conservation instructional modules,
* an activity package for use by individuals or groups of students within a classroom situation, and
* a reference guide describing exemplary conservation activities, for use by student groups and vocational organizations outside the classroom setting.

These materials are designed to be flexible and adaptable to a variety of instructional contexts and modes (e.g., individualized or group instruction). No prescribed instructional sequence for using these materials is stated. The materials are intended to: introduce students to the facts regarding efficient energy use, energy conservation, and energy waste; present information to help students understand the personal contributions they can make to solving the energy problem; and provide instruction in nontechnical energy conservation practices that are specific to the vocational discipline and the particular occupation in which the student is being trained.

Project findings and conclusions
The reasons for practicing energy conservation are many. In brief, conservation is the least expensive, most reliable, safest, and least polluting energy resource available to us. As indicated in the literature search and occupational analyses, we have the technology to implement energy conservation practices without economic hardships, but there continue to be informational and attitudinal barriers to conservation. People may not conserve energy because they do not believe that an energy crisis exists, or because conservation practices are inconvenient (presumably due to the presence of higher or conflicting priorities). On the other hand, they may be simply unaware of available conservation techniques and practices; or ignorant of the relative amounts of energy consumed by different devices, and the range of conservation actions and options available to them (Baird & Brier, 1981).[4] If people are not adequately informed about energy facts, they cannot make wise decisions regarding energy use and managment.

There is generally a lack of energy education instructional materials that can be described as worker-oriented and designed for use by students in vocational education training programs. The instructional strategy undertaken by AIR in developing materials in the area of energy conservation has implications for the scope and content of future materials development efforts.

When determining the vocational education courses for which specific materials, such as energy conservation instruction materials should be developed, educators must carefully evaluate current and anticipated student course enrollments and the impact the worker conservation behaviors could be expected to have in each content area. Materials should be targeted to grade and subject matter areas, and designed to mesh with ongoing educational activities. In addition, any materials development effort should equally reflect relevant social values and issues as well as current economic, industrial, and commercial concerns.

However, the development of effective, accurate, and comprehensive instructional materials is not sufficient to ensure the use of the materials. Two necessary elements that must be taken into consideration in planning an instructional development strategy are: (1) future provisions for revising the materials, as necessary, to incorporate new information and up-to-date facts, thereby maintaining the accuracy of the materials; and (2) dissemination and distribution plans to inform people of the availability of materials — what they look like, the audience at which they are aimed, how much they cost.

The response of the vocational education community to these materials strongly indicates that energy education, in general, and particularly energy conservation, is a high priority for vocational education. The responsibilities for vocational education include training workers in energy conserving practices and skills; integrating energy concepts, techniques, and skills into existing programs; and helping students develop an awareness of the value of their personal contributions in responding to the energy problem. The instructional materials being developed at AIR represent an integrated effort between an identified educational need and the functional skills demanded by a changing society and changing workforce needs. The direct outcome of this venture is the development of curriculum materials that are current and relevant to our social and economic situation.

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11.4

A STUDY IN ENERGY CONSERVATION

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Community colleges enjoy a tremendous potential for service in the area of energy conservation because of their unique position within the structure of their communities, and because their objectives are so closely related to the welfare of the people they serve. Daytona Beach Community College has taken an active and enviable role in promoting energy conservation on the local levels since the desastrous 1973 international oil embargo. When imposition of fuel adjustment costs resulted in increased electric power bills for our campus, efforts were made to reduce both demand and consumption of power. It was clear to us that unless serious conservation practices were promptly instituted, the increase in energy costs would soon outweigh the effects of any of our conservation efforts. Preliminary auditing provided information which indicated a need for more comprehensive technical examinations of the buildings. The chairman of our Air Conditioning/Refrigeration program was given the responsibility of making DBCC an energy efficient campus. He began by instituting a course for outstanding students who were graduates of the regular Heating, Ventilating and Air Conditioning program, skilled and motivated for energy conservation, and excited at the prospect of being involved in saving energy and money. It quickly became apparent that a systematic approach must be organized with concern for appropriate sequence of conservation measures, and budget dollars. We decided that our program must be self-supporting, and that initial savings must support subsequent phases.

Ultimately, energy consuming equipment must operate efficiently, and only when necessary. Our Energy Conservation Applications course proved that preventive maintenance of electro/mechanical equipment was sorely lacking. We concluded that unless, and until appropriate maintenance is employed, little could be accomplished. Other colleges have done much in the areas of audit and engineering. Experience proved that poor maintenance can and will negate some or all of the retrofit efforts. Our main thrust is in the area of energy conscious preventive maintenance, with accent on heating, ventilating and air conditioning control systems and strategies. Our energy students learn the technical aspects of hydronics, and control systems and strategies, with an ever present thought for energy consumption.

In 1979, Daytona Beach Community College was the $10,000 grand prize winner for its Energy Conservation Applications program, conducted by students and instructors. DBCC competed with such prestigious institutions as Purdue University, Duke University and Brigham Young University for the prize in the Cost Reduction Incentive Awards program, sponsored by the National Association of College and University Business Officers (NACUBO) and the United States Steel Foundation. NACUBO and United States Steel officials stated, "The manpower furnished by DBCC students is the major factor in the program's success. The entire project has widened the scope of influence of an educational program, while broadening the employment opportunities for experienced graduates."

DBCC introduced its award-winning Energy Conservation Applications program in 1978 as part of its regular curriculum. Students used the College's own facilities as an open laboratory which gave them experience in making adjustments under actual operating conditions. Our students examined eight of eighteen buildings in 1978. The study resulted in reduced energy consumption and a savings of $37,942 in energy costs as compared with 1977, and $39,019 comparing 1976 costs. The reduction of electricity, gas and oil was accomplished even though there was an 18 percent increase in student population, an additional 31,600 sq. ft. of floor space, and a considerable additional load from other electro/mechanical expansion.

Less than $500 was expended for the retrofit to accomplish these savings and proved that many energy conservation programs can be accomplished on a local basis. Conservation for a majority of people connotes a sacrifice in order to save. The application of conservation guidelines at our institution led directly to more effective use of HVAC systems and equipment while greatly improving the environment for less cost. We realized double dividends by a careful check of operating effectiveness and appropriate corrections. The successful results from the energy conservation activities of the campus and the high degree of qualification of the recent graduates of the Energy Conservation Applications program indicates a tremendous opportunity for us to be of service to other governmental agencies in our service area as well as the heating, ventilating and air-conditioning industry in the State of Florida. Revision and expansion of present courses and activities, however, is a necessity.

As a specific service to the community which we serve, we have proposed that the College spearhead a community energy conservation educational program. A proposal is underway to take the expertise of the College faculty and students into the community and plan a steering committee of the civic and business leaders who will arrange a hands-on educational program to benefit the management of the area's motels, restaurants, service establishments, mercantile facilities, entertainment and transportation facilities. During calendar year 1981, we propose to make our campus *THE* center for energy information. This center will include a library of energy information where citizens may come and read or research their energy needs and ideas. An energy demonstration house is being developed to provide live, on-site reality. The community is indeed involved in this program and we have contributions of central water to air heat pump with waste heat recovery, solar hot water heater system, additional attic insulation, and many other energy conservation devices. Thus far, all energy devices and materials have been donated by merchants, contractors, and utilities. The blend of government, industry, and consumer is important because the cooperation of each is necessary to organize an integrated program. The program will help business communities save energy and money as the College has done within its own physical plants in Daytona Beach, New Smyrna Beach and DeLand, and as other towns and cities have done. The primary local benefits will be the improvement of the area's energy supply with the resultant savings used to attract more visitors to our area. The energy in financial savings from the area-wide project are a drop in the national bucket of energy conservation and the pioneer program will serve as a catalyst for projects elsewhere.

On July 1, 1980, we appointed a Director of Energy Management, and organized an Energy Management Department. The Director of Energy Management is responsible for:

a. teaching the Energy Conservation Applications course

b. directing the in-house preventative maintenance program for electro/mechanical equipment

c. identifying energy conservation opportunities, determining feasibility, return on investment and effect on energy related services to the campus.

During fiscal year 1980-81, the Energy Managment Department returned to the College approximately 50 percent more in dollars than the department's operational cost. The reduction in costs were involved with reduction and energy cost avoidance, reduction of maintenance costs, and alteration of billing schedules. Fiscal 1981-82 promises to be a rewarding year. We have five main goals in energy this new fiscal year.

1. An emergency contingency plan is being organized in order that college services to students will continue, in spite of an energy emergency and curtailment of available energy.

2. The energy demonstration house will provide awareness in the community we serve, and provide ideas, and knowledge to successfully carry out those ideas.

3. The Director of Energy Management will write a weekly newspaper column. The weekly column, together with the energy resources reading room and the energy demonstration house on campus, will further the awareness program, and hopefully, encourage citizens to act to avoid high energy costs and use.

4. Our $10,000 cost reduction award has been earning interest since 1979. We intend using it as matching funds for an electronic energy management system. Our interbuilding communcations conduit is in place and we are presently writing specifications for the hardware.

5. We continue to believe that energy efficiency is a function of good preventative maintenance, and is an ongoing process. We are promoting the most important requirement of the electro/mechanical technician. The technician must be skilled, energy conscious, tactful, and the results of his efforts must be recognized as important and vital to society.

I am grateful for the opportunity to be with you, to tell you about the energy program and the energy curriculum at Daytona Beach Community College.

11.5

SOLAR ENERGY FOR THE MASSES

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This paper combines the methodologies and program details used by the authors to make solar energy meaningful to the general public.

The comprehensive approach employed by the authors begins at the community college adult education level. The use of this wide-spread, community-based educational system is an appropriate platform from which to teach about decentralized energy systems. Additionally, the community college system presents an affordable alternative to most people.

Working from this platform, the authors translate the technical theory of solar energy into an easily assimilable and comprehensible data set. The methodology practiced carries the student beyond the stage attainable through self teaching. The approach provides a more in-depth understanding of the physical laws and technical capabilities which govern the basic principles of energy education. These basics are taught through an integrated variety of discussions, media and lecture approaches aimed at providing the student with enough information to make practical and applicable use of solar energy technology. Included in the curriculum is sufficient information and insight for the student to recognize false and misleading advertising so prevalent in today's energy marketplace.

The authors have developed and used the methodology described in this paper in teaching several hundred students in recent years.

SESSION 12: CURRICULA - VOCATIONAL TECHNICAL

12.1

THE DEVELOPMENT OF FACULTY ORIENTED PROGRAMS TO MEET ENERGY WORK FORCE NEEDS

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Introduction

The Solar Power Institute (SPI) is a non-profit organization whose purpose is to encourage the use of solar technology wherever it is economically feasible and in the best interest of the country. Since its inception the Solar Power Institute has worked closely with a number of educational institutions in the state of Connecticut, primarily the University of Connecticut, Central Connecticut State College and the E.C. Goodwin Vocational Regional Technical High School. In addition there has been the normal contact with state and federal agencies and the commercial sector particularly as it relates to the activities of the SPI and its program funding needs.

One of the main activities of the SPI has been the offering of programs, e.g., training courses, to help increase the knowledge and capacity of those working with solar energy and to promote the industry standards needed to achieve a public acceptance of solar energy with emphasis being given to the proper design, installation, operation and selection of solar systems. The prime audience has been teachers in the vocational technical schools and the industrial arts area. This group is singled out because of their responsibility in training the craftsman or the tradesman. These are the individuals who have a significant role in the commercialization of solar technology. Although teachers have been the prime target, the SPI course offerings have been taken by contractors, energy educators, engineers, retirees and by individuals who are working in an energy advisory capacity or who feel that solar energy is one direction to go in the future.

The cost of the SPI course offerings were to be covered by student fees, but this has not been the case. Instead, financial support was sought from philanthropic groups and industry with these monies being used for student stipends and instructor salaries. An educational program of this nature and importance should not be dependent on private funding.

The SPI educational seminars are a coordinated effort. This is to say that every effort is made to blend the theory and research from academic programs and the government areas with the technological skills provided by the vocational technical schools. Emphasis is placed on presenting meaningful practical knowledge. The basic theory presented is of the magnitude to provide an appreciation of what is involved in the proper design, installation, operation and selection of solar systems. Theory is combined with actual practice by including the installation of a residential solar water heating system in a one week course offering. The success of this endeavor is evidenced by the favorable course critiques that have been received at the end of the session.

A series of one day seminars has also been presented to meet specific needs, e.g., a solar system installation inspection seminar for building officials. The seminar was in response to a field need. It was based upon the experience of the University of Connecticut Mechanical Engineering Department in the conduct of the U.S. Housing and Urban Development (HUD) inspection program. Also involved was the University of Connecticut Cooperative Extension Service.

Program

This past year the institute expanded its course offerings to include installaton of wind energy systems, solar assisted heat pumps, photovoltaic conversion and bioconversion.

A one week session is set up as follows. Course attendees arrive on Sunday evening and are greeted with a get acquainted hour which includes refreshments. Course introduction starts at 8:30 AM the following morning. Daily program sessions run until mid-afternoon. There is a morning coffee break and a soft drink breat at mid-afternoon. Attendees are together for lunch.
From mid-afternoon until after evening dinner, the course attendees are on their own. This fee time can be utilized for further study, discussion or relaxation. With these sessions usually being held on a college campus, facilities are available to the attendees. It is our feeling that by mid-afternoon the attendee welcomes this break and that it is essential in a one week long program.

In the evening, there is a follow-up session for up to two hours to review and discuss questions arising from earlier in the day. These sessions are quite fruitful when there is a good audience, mixed in discipline and fields. In our opinion, it is a vital key to program offering success.

To conduct such a course demands that the attendee remain overnight. This results in an added expense, but it is more beneficial from the learning process and the program purpose. Daily commuting from any distance is discouraged. It makes for an extremely long day and the attendee loses the sense of feeling for being a course participant. Varied course time schedules have been tried, i.e., commuting and non commuting, all day sessions versus that described.

A two or three person instructional team is used plus a program coordinator. The program coordinator permits the instructional team to concentrate on course offering while the program coordinator scores as a floater, picking up the necessary details which can arise during the course of the week. For example attendee needs, unanticipated program problems, xeroxing, intermingling with the attendees for session feedback and administrative matters. Advantages of the team approach are voice change, background and outlook differences, and flexibility in being able to adjust more readily to the audience as the need arises.

Selection of personnel is critical. For example, one can teach a course from subject matter, but in our opinion, this may not be enough. If actual experience can be included, this should be sought out. It strengthens what is being presented based upon the knowledge currently at hand. A distinction is made here between the customary classroom approach and the target audience which is sometimes overlooked in an educational program at this level.

Observations
The development of a faculty oriented program to meet energy work force needs involves the selection and obtaining of highly qualified personnel, curriculum development and funding. In terms of inputs to these areas by the SPI, the greatest time allocation has been devoted to obtaining funds for program support. Although the SPI courses are well publicized, costs are a significant factor. Many people have sincere interests in attending if subsidized, but not if financial support is lacking. How does one interpret this? A lack of interest on the part of the teaching faculty or are we overlooking something in an energy education process need?

As an overview to the SPI program, it might be worthwhile to cite some of the critique comments received at the end of a course offering. These comments followed: "I would recommend this course to anyone with a serious interest in solar"; "I now have enough background to go out and teach the subject and to continue research as well"; "The most effective course I attended"; "This course in many ways will constitute better counseling for the consumer"; "An excellent learning experience"; "A course that can't miss!". Comments received such as these reflect a need fulfilled.

Varied educational approaches in energy education are needed. Their value must be related to a purpose. A one week in depth course offering such as that outlined earlier has certain advantages over a series of once a week three hour sessions over an extended time period at the end of a working day or a one day seminar. There is a learning environment which other methods cannot as easily achieve. The theory-practice concept can be handled more readily because of the time period available. Is the added cost worth it? From an energy point of view, an energy work force and the learning process our answer is "yes". It is the SPI's observation that the practical handson experience of an actual working system that will be permanent is a plus. SPI courses attendees have found the approach a knowledge asset which they have not been able to experience in other courses.

What are some of the obstacles being encountered in the development of a faculty oriented program to meet the energy work force needs? A major obstacle can be funding. We say this recognizing that there has been a reasonable number of dollars spent nationally in this area. A question here is the expenditure of the dollar for the educational purpose. For example, an agency or group having state or federal funds may decide to develop their own educational program. This is certainly acceptable if it is needed. However, depending upon the circumstances, it may be more desirable to channel the program through other groups already set up for this purpose such as existing educational institutions or specific independent groups. A review of the SPI's funding experience from national, state and local level follows:

Funding:
Federal funding for faculty development courses are accepted from any accredited four-year college, university, community or junior college, or two-year post-secondary technical institution; and from non-profit science museums and science centers. This excludes a non-profit organization such as the SPI.

State funds are much sought after by too many groups for too few dollars and leave very little funding for faculty development energy education. This is particularly true for vocational technical and industrial arts teachers.

Municipal funding at the local community level is difficult for a teacher to secure in order to attend a summer workshop on energy technology.

We note that educators prefer an after school year educational program, especially during the summer months. For example, a one or two week workshop. This interest is there on the part of the teacher, providing the course offering is available at no expense. One can argue that if the teacher is truly interested the teacher will attend. If the subject matter area, energy education is important, then budget expenditure would be worthwhile. At one time the SPI had an indication that 980 educators from 12 states were interested in attending its course offering if financial support was made available.

Enrollment History:
: A matching grant was offered by the Connecticut State Department of Education and SPI in 1979. This resulted in having 126 educators willing to attend the course offering with no stipend or reimbursement for travel expenses.
The SPI offered a matching grant without state funding in 1980. The cost to the educator was $190. RESULTS: Six enrollments, a 96% reduction in enrollment from the previous year. In 1981 the SPI repeated its 1980 offering of a grant without state funding. RESULTS: Three enrollments, causing a 98% reduction in enrollment. Therefore, in order for SPI to continue its educational purpose, private funding was sought. Its success supported the following:

150 Educators
75 Building Officials
22 Contractors
15 Energy related officials
5 Engineers

Closing Remarks
Approximately 600,000 jobs will create the energy work force.[1] A high percentage of the jobs will be filled by the non-collegiate sector. Yet, most of the federal funds for education are allocated to colleges and universities. We feel that the vocational technical schools and industrial arts area could make a valuable contribution to our national energy work force needs. This group is deserving of increased attention and financial support. With continued funding and perhaps a rethinking of energy education funding policy, groups such as SPI and other nonpublic educational bodies can survive and hopefully address the energy education needs of today and tomorrow. The SPI is prepared to schedule programs to suit a particular areas needs on a "world wide" basis.

12.2

ILLINOIS SOLAR '80: A PASSIVE SOLAR CONSTRUCTION PROGRAM FOR VOCATIONAL BUILDING TRADES

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Abstract
Illinois Solar '80 is a residential passive solar construction program targeted at Illinois vocational schools traditionally involved in home building projects. Conducted by the Illinois Institute of Natural Resources (INR), the first round of this program has resulted in the construction of 18 energy efficient passive solar homes by 17 vocational schools throughout the state. The major program components of Illinois Solar '80 are: 1) an open solicitation process, 2) professional training in passive design and construction, 3) $1,000 grant award to each school, 4) technical assistance, 5) promotional support, and 6) site visits. A total agency investment of $29,000 in direct costs has resulted in training over 650 building trades students in passive solar design through construction of 18 solar homes.

Introduction
The Institute of Natural Resources in the strategies to achieve this goal, identified two major barriers. First, the home building industry has had limited experience in constructing passive solar homes. Without some formal training, the introduction of passive solar construction into the marketplace would be delayed. Second, as with all new technologies, there has been a general lack of public awareness and acceptance of the benefits of passive solar construction. Our goal was to design a program within the constraints of limited resources that could concurrently address these two issues.

It became apparent that the vocational education network, with its state-wide financial and educational resources, was an ideal vehicle for our efforts. In Illinois alone, over 100 homes are built each year by high schools, vocational centers, community colleges and universities. This represents thousands of students throughout the state who are directly involved in the construction process itself. Also, thousands of other students enrolled in related programs such as architectual drafting, interior design, landscaping, and real estate are often involved in building trades projects. In addition, schools are generally viewed as credible institutions in their communities and their involvement would lend legitimacy to passive solar utilization. Illinois Solar '80 was initiated in the spring of 1980. The first cycle of this program has resulted in the construction of 18 passive solar homes by 18 vocational schools throughout the state and the direct training of over 650 building trades students, Illinois future construction work force.

Program operation
Our basic approach throughout the Illinois Solar '80 program has been to familiarize building trades instructors with the fundamental concepts and practices of residential passive solar energy and to develop their capability to incorporate passive design into classroom instruction and project homes. The basic program components are as follows:

Open Solicitation
All Illinois schools involved in home construction projects were eligible to participate in Illinois Solar '80. Most schools were contacted by mail. Since a complete mailing list of home building trades programs is not maintained at the state level, a more complete list was developed using the conventional vocational network (i.e., conferences, newsletters, personal contacts, etc.). A simple package of information was sent to each school's principal and building trades instructor consisting of:

a) Introductory letter - Signed by the directors of both INR and State Board of Education, it announced the program, and more importantly, endorsed its objectives and encouraged school participation.

b) Program announcement - Defined the goals, requirements and selection criteria for participation in Illinois Solar '80. Our minimal requirements were that each school 1) send a design team to attend the training workshop, (we suggested that each design team be comprised of a building trades instructor, a project manager, and a local consultant, 2) construct a passive solar house, and 3) document the construction process.

c) Application - Requested a basic history of the building trades program, including the number of homes built, number of students, design team members, budget, construction timetable, related education programs and community resources.

d) Home design books - Contained design renderings and basic floor plans, cost estimates and highlighted special features of passive solar homes developed by the Mid-American Solar Energy Complex (MASEC) and the Tennessee Valley Authority (TVA).

Training
The formal training for Illinois Solar '80 consisted of two two-day workshops. The first, conducted prior to construction, addressed the fundamentals of residential passive solar design and construction. Attendance at this workshop was required for participation in the program.

The second and more advanced workshop, was timed to coincide with the school's planning process for the next's year's construction project. It was also an opportunity to critique and review their progress on their current project houses. Participants found both workshops to be a very attractive and useful feature of the program.

Common to both workshops were the following elements:

a) Professional training: Our presenters covered topics including the fundamentals of passive solar design, specifics of energy efficient construction, landscaping, marketing and methods of classroom instruction.

b) Designs: It was critical to have working plans available for review and discussion. We provided plans developed by MASEC and TVA; however, schools were encouraged to use original plans that could accommodate passive solar techniques or to modify the designs we provided.

c) Materials: A variety of resource materials were compiled by the Institute and provided at the workshop. We selected information that addressed a wide range of topics including design and construction details, methods of energy analysis, interior design, and economics.

d) Expenses: INR paid travel expenses, lodging and meals for three representatives from each school to attend both workshops.

Direct Financial Aid
Each school received a $1,000 grant. These funds could not be applied to any of the costs directly associated with construction. Eligible uses included additional training, consulting services, curriculum materials, equipment and related expenses.
While the grant was initially offered to attract schools to the program, our experience indicates that it is not an essential element: in fact, each school plans to continue building passive solar homes without additional funds from INR.

Promotional Support
Once enrolled in the program, additional grants up to $500 were made available to schools who wished to conduct local solar events. Possible activities included open houses (a traditional feature of building trades programs), home tours, workshops, fairs, public service announcements, production of visual aids, etc. The events were targeted towards builders, architects, real estate agents, lenders and local government officials, as well as the general public. In some cases, neighboring Solar '80 schools combined financial resources in order to reach a wider audience. While this aspect of the program was optional, it was advantageous to both INR and the schools that these funds be used. In addition to providing an ideal opportunity to educate the public about passive solar energy, these events ultimately helped to promote the sale of the house. Although INR made funds available and offered support services, the format and focus of the event was developed by the individual schools. We felt it was important that the school initiate community education in passive solar energy. Our role was to support their efforts rather than to dictate their results.

Technical Assistance
Design and construction assistance was provided by INR's solar architect and mechanical engineer upon request. In addition, INR's Solar Speakers and Consultants Bureau, a state-wide listing of solar experts, was used to refer schools to experienced people in their own communities.
The staff engineer was responsible for providing each school with an energy performance analysis of its home. This analysis enabled the schools to fully understand both the positive and negative impacts of their design or construction modifications.
Finally, information about current events in the solar industry and the home building trades profession was regularly forwarded. This information included product updates, technical reports, announcements of upcoming seminars and conferences, newsletters, and other items of interest.

Site Visits
Each school was visited by the INR staff several times during construction. These visits enable us to review their program, identify specific needs and provide technical support on an individual basis. It was stressed that these visits were not inspections, but rather an opportunity to provide support and encouragement. Moreover, these visits indicated to the schools that we were genuinely interested in their projects.

Future directions
Presently 27 schools have applied for participation in the second of three planned program cycles. It has always been our intention, regardless of the impact of expected reductions in federal funding, to phase out the formal operation of this program after the third cycle. By 1983, having reached 50 percent of the schools that build homes in Illinois, we feel that an adequate passive solar construction network will be in place. (We plan to continue to provide technical assistance to this network as needed.) At that point, we will have been involved directly or indirectly in the construction of more than 125 passive solar homes. More importantly, 5,000 future builders will have been directly involved in the construction of energy efficient passive solar houses.

We believe this program will, over time, significantly affect the residential construction market in Illinois. Our experience indicates that once builders are introduced to the technology, the use of passive solar energy sells itself. As one building trades instructor told us, "We will never again NOT build a solar home."

12.3

PROJECT S.U.E.D.E.: A MODEL FOR COMPREHENSIVE SOLAR SKILLS TRAINING

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Abstract
Many new training programs are trying to meet the current and anticipated need for workers with technical skills in solar design and construction. Project S.U.E.D.E. (Solar Utilization/Economic Development and Employment) was a federally funded demonstration program intended to create a model for training solar installers.
This paper will discuss the following aspects of the S.U.E.D.E. training model: curriculum, hands-on training, homeowner education component, gender issues in a technical training project, and applicability of the training to the solar job market. The S.U.E.D.E. Project is evaluated as a model for training solar technicians, with recommendations for applying this model to other energy training programs.

Introduction
The New England S.U.E.D.E. Project was one of fifteen federally funded solar demonstration training projects taking place throughout the country. On the national level, the sponsoring groups were the Departmen tof Energy (DOE), Community Services Administration (CSA), and the Department of Labor (DOL).

The focus of this paper will be the experiences and lessons learned through Project S.U.E.D.E., administered by the Cooperative Extension Service, at the University of Massachusetts in Amherst. The Amherst S.U.E.D.E. Project was one of three training sites in a four group consortium, S.U.E.D.E./New England. This consortium was composed of the following organizations: the Energy Education Center, University of Massachusetts, Amherst, MA; Southern New Hampshire Center, Manchester, NH; Total Environmental Action Foundation, Harrisville, NH; and the Center for Ecological Technology, Pittsfield, MA. The training guide was developed as a collaborative effort of these four groups, with slight modifications made at the discretion of the different trainers at the three training sites.

Project goals

As the title Solar Utilization/Economic Development and Employment implies, this was a project of ambitious scope. Project S.U.E.D.E. had three major goals:

1. to develop a suitable curriculum to train CETA participants to understand, design, build and install solar heating devices.
2. to demonstrate that relatively low-cost solar systems work effectively to lower the fuel bills of low-income households.
3. to expand the market for passive solar systems by creating a number of visible and attractive working examples of solar systems on typical residences.

At the completion of the project, one hundred and five solar systems had been installed by the S.U.E.D.E./New England Consortium, with twenty-nine of the systems having been completed by the Amherst S.U.E.D.E. group.

Classroom training

The nine month project was divided into a three month classroom segment, followed by a six month field component involving system installation on existing homes.
An average day of training allowed for four hours of lecture, slide or film presentations, followed by four hours of hands-on shop activities. Eight hours of classroom training a day for 65 days totaled 520 contact hours.

The following performance objectives were established for the trainees: the ability to:

1) assess a site for solar suitability
2) choose and design a passive solar device
3) calculate that systems thermal effectiveness and pay back period
4) draw plans for the construction of the system
5) install one of the three S.U.E.D.E. designs onto an existing residence

Trainees were treated as workers and not as "students." They were paid full wages during the classroom training segment. Breaks and lunches were scheduled as in a typical workday. Trainees received sick days and health insurance. No homework was assigned outside of the classroom, and reading time was provided during the regular workday.

The S.U.E.D.E. training program is designed for people who are able to participate full-time and are not already engaged in any kind of employment activity. This aspect of the model would have to be significantly changed to be useful in training people already employed, who wanted to receive training on a part-time basis, because they cannot commit 40 hours a week to being in a training situation.

The training curriculum

A training guide was developed providing each participant with an outline of each day's presentations, including references to additional resource material. The entire course outline was divided into seven curriculum units:

Unit I - Energy Overview
This section provides information on the political and economic aspects of U.S. and world energy consumption and production. The unit reflects a concern that the trainee be able to converse with the homeowner about the social reasons for the development of passive solar technology. Role playing was used to give trainees practice talking to potentially skeptical homeowners. This section presented information about solar energy use within the larger context of the "energy crisis".

Unit II - Bioclimate
This section presents the criteria for thermal comfort. It includes human physiology, microclimate, existing housing, and energy conserving sun-tempered housing. A field exercise in micro-climate mapping is included in this unit. This section stresses the concept of thermal comfort as a measure of the effectiveness of the heating system.

Unit III - Heating Systems
This section familiarizes trainees with existing heating systems and their comparative merits. The system covered were wood, oil, gas, and electric fuel systems. This unit teaches the integration of the solar retrofit system with the existing heating system.

Unit IV - Weatherization
This section teaches the theory, materials and techniques of energy conservation. Standard heat load calculations are taught with an opportunity for practice during site selection. Life style management was also taught during this section.

Unit V - Solar
This section presents the fundamentals of solar theory starting with the sun/earth relationship, and continuing through to the collection, distribution and storage of solar energy. Heat gain calculations, glazing and other materials, shading and other obstructions, thermal shutter design and theory, active systems, and sizing calculations are included in this unit.

Unit VI - Hands-on Workshop Sessions
Trainees divided into crews with a crew leader for hands-on workshop sessions that usually occurred each afternoon. Presentations given by the crew leaders include use of tools, safety, blueprint reading, and directions for the actual building projects. Projects to be constructed include sawhorses, toolboxes, test collectors, shading masks, heliodons, and sheds.

Unit VII - Drawing Skills
This unit includes architectural drawing, lectures, exercises in elevation drawing, and reviews.

Presentation Methods

Technical information was taught by a combination of lecture presentations, slide shows, films, group discussions, and small group research projects and presentations. The hands-on projects were integrated into the curriculum to reinforce the theoretical concepts being taught in the classroom segments.

Each trainee and instructor was given a curriculum guide which provided outlines for all the lectures, referenced this material, and provided additional readings to accompany each of the sections. Each training site had its own small reference library.

The contributions made by the skilled and dedicated training staff cannot be underestimated. The expertise of the trainers in solar, construction, and energy conservation was key to the overall success of the training project. Trainers often put in eight hours a day of teaching time with little preparation time planned for in the curriculum guide. S.U.E.D.E. presented both trainers and trainees with an intensive schedule.

Field Component

The field component follows the classroom training segment of the training program. The field component includes: choosing residential sites based on their solar suitability and construction feasibility; performing a heat loss calculation for each potential site; choosing and modifying the design of the solar system; drawing elevation plans of the system attached to the existing home; developing a materials list; installing the system; and homeowner education. During this component, the training staff provided field supervision for all aspects of the construction process.

S.U.E.D.E. As a Training Model

Project S.U.E.D.E. should be credited for its comprehensive approach to using a curriculum broad enough to encompass the study of the energy crisis, and homeowner education techniques, as well as a thorough examination of the most current technical information needed to become a competent passive solar designer and installer. A more streamlined training might be a possibility for future projects, but the comprehensiveness that the S.U.E.D.E. training emphasized would have to be sacrificed in the process.

The number of quality installations completed during the S.U.E.D.E. Project shows the success of the project in meeting its original performance objectives. Sophisticated skills were transferred to trainees in a relatively short time span. After three months of classroom training previously inexperienced workers were out in the field building low-cost solar systems on low-income homes. This accomplishment speaks for the merits of the S.U.E.D.E. training program.

Homeowner Education

The S.U.E.D.E. Project demonstrated the importance of homeowner education. The homeowner's satisfaction with the system and the thermal comfort they were able to enjoy, was a product of their understanding and appreciation of how their system worked, and of their willingness to become involved in the day-to-day operation of the system. Examples of the active participation required of homeowners are the manual operation of the night time insulation for both the greenhouse and direct gain system, or the ability to recognize and correct a failure of the back draft damper in the thermalsiphoning air panel.

Homeowners were selected for participation in the project on the basis of three main criteria: 1) income eligibility - homeowners needed an income less than 125% of the federal poverty line for their size family; 2) their home needed to meet the technical requirements - orientation, shading, construction feasibility, and energy efficiency; 3) they needed a cooperative attitude that would contribute to the overall goals of the project. The project grant did not allow for any conservation measures to be applied in addition to the solar system. Sites had to be found which met the weatherization and insulation standards established by the site selection process. Each system would be expected to reduce fuel consumption by a minimum of 15%. Since eligible participants were required to be low-income, many of them were also eligible to receive assistance through the county weatherization programs. At times it seemed like a contradiction of terms to find well insulated homes among low-income homeowners. A future improvement for this type of program would be to combine the installation of low-cost passive solar systems with already existing weatherization efforts so the two processes could happen as an integrated effort.

The homeowner component of the Amherst S.U.E.D.E. Project was under the auspices of the three member outreach team. An evening session was held once in three different parts of the region so that the locations (town halls or libraries) would be convenient to the homeowners. Attendance at the homeowner sessions was mandatory, and was part of the signed agreement between the homeowners and the project.

The homeowners had been previously informed as to which system they were going to be receiving. During the homeowner education session, presentations gave information on the mechanics and maintenance of the three S.U.E.D.E. systems. These three systems are attached solar greenhouses, vertical wall thermosiphoning air panels, and direct gain systems. There was also a brief introduction to horticultural management of solar greenhouses. Construction timetables were laid out, and the homeowners were given an opportunity to meet the folks who were going to be cutting into their south wall. They were encouraged to ask questions, both technical and non-technical.

Including homeowner input into the design and construction process was important. They were included into the construction planning process as much as possible so that their lifestyle and their intended use of the system could be taken into account. For example, people who were intending to use their greenhouse for horticultural purposes had the design option of having glazing in the end wall of the greenhouse. Recipients of the direct gain systems were educated on the benefits of using the thermal curtains that would be supplied as part of the project. The homeowner education sessions stressed the importance of "conservation first," which encouraged them to further their efforts to make their homes as weathertight as their means permitted. Trainees were encouraged to use the time on-site during the preparation and construction processes to provide the homeowners with additional energy information.

In an analysis of the monitoring data collected by the Center for Ecological Technology under a small follow-up grant by the Community Service Administration, the data reinforces the notion that the homeowner is important in determining the thermal performance of the passive solar system. In general, the S.U.E.D.E. solar systems contributed between 15-30% of the homes heating requirements. In certain cases, the fuel use reduction was greater than the theoretical capabilities of the system. This was accounted for by the fact that the addition of the system created a warm room during the day which allowed the inhabitants to change their lifestyle, using the warm room more and lowering the thermostat setting for the rest of the house thus enabling less fuel to be used in the non-solar tempered part of the house. This and similar changes in patterns of fuel use were influenced by the homeowner education aspects of the project.

Gender issues
In the training component of the S.U.E.D.E. Project, there were gender issues among the mixed group of men and women trainees who were taught both technical and trade skills. Both solar and carpentry are non-traditional skills areas for women. Unfortunately, this paper does not allow the space needed to present a theoretical base for discussing the complex and sensitive issue of sex roles in relationship to a training situation. However, a few important points will be highlighted.

In our culture, an expectation is that men will be more competent than women in both technical and construction skills. It is considered "legitimate" for men to have experience and expertise in these fields. The mixed group setting of the training component provided an opportunity to challenge the traditional sex-role expectations. As women proved themselves competent in technical and carpentry skill areas, expectations changed.

In the administrative/trainer component of the S.U.E.D.E. Project, men filled two of three positions of authority. The one woman trainer, very experienced in solar construction, had to struggle to maintain participation in the decision-making process, and her expertise was challenged by the Training Director. Yet the fact that there was a competent woman administrator provided the trainees with a valuable role model of a woman demonstrating her leadership abilities. In the leadership heirarchy among trainees, all three crew chiefs were male.

The co-ed training situation was sometimes difficult for the men entering the project with few of the manual skills needed, since this is contrary to the traditional expectations of men. In general, men were competitive with each other in appearing skillful and knowledgeable. Among the women trainees, it was stressful to be in a small group learning situation with a crew of men, especially when using power tools and construction materials.

To counter the isolation experienced by women trainees as a result of being in a crew of all men, the women occasionally met together on breaks. These singular sex meetings were opportunities for women to discuss feelings about the male/female issues raised by the dynamics of a co-ed training program. These informal meetings of women were viewed with suspicion by the men.

It would be advantageous for future training programs to build in structured groups exercises and support mechanisms that help bring these emotionally charged issues around sex role expectations out for discussion early on in the training for the development of cooperative working relationships.

Solar job development
It was hoped that S.U.E.D.E. would prepare people for entry into the job market at a number of levels. "Multi-level" entry options may be available for positions in the job market such as solar designer, consultant, contractor, technician, and trades apprentice. Within six months after the completion of the S.U.E.D.E. Project, approximately half of the trainees found energy related work.

A general observation was that those who came in with prior carpentry and technical skills went out with qualifications for the best jobs. It was over ambitious to expect trainees to be skilled craftspeople after only nine months of training. Those with previous carpentry experience needed only to add solar knowledge to existing skills. Solar skills can be taught in a relatively short amount of time, whereas skilled carpenters cannot be turned out in such short order.

The CETA Dilemma
As a project using CETA eligible people, there was an element of excitement in the prospect of taking previously unskilled workers and training them to be competent solar installers. However, in some ways, this may have been the undoing of the S.U.E.D.E. Project. The linkage of the S.U.E.D.E. program with CETA kept S.U.E.D.E. from receiving continued funding at a federal level because, in the fall of 1979, CETA suffered much unfavorable publicity. As a result, the Department of Energy no longer wanted to utilize CETA labor for S.U.E.D.E., and no other monies were appropriated. This was an unforeseen political complication.

Appropriate Targets for Solar Training
Targeting solar training for workers without prior skill training in the trade may have been a misdirection for the project. It may be more realistic to see solar as a specialization area for workers with existing building trade skills. Many studies researching the future employment opportunities in the area of solar installation predict that most jobs will exist for workers already practicing in one of the related trades--carpentry, sheetmetal, plumbing, masonry, etc. Solar skill training might be most appropriately used as a way to upgrade existing workers, the study *Solar Energy Employment and Requirements 1978-1985* prepared for the Department of Energy states.

Based on the reported new skills and knowledge required, there appears to be a need for persons trained in the design and analysis of solar units, and for persons trained in the installation of solar units. However, no new occupations unique to solar energy emerged as a result of this question, and a majority of respondents (including a majority of installers) did not regard the tasks performed as substantially different from traditional tasks. It appears that employees must be capable of performing traditional as well as purely solar work.
In the larger scope of things, it seems contradictory to be training unskilled workers to be constructing solar installations, as in the case of the S.U.E.D.E. Project, which relied primarily on carpentry skills, while at the same time skilled area carpenters were unemployed or underemployed.

The Union Issue
Some of the S.U.E.D.E. Projects conducted in other parts of the country faced criticisms from trades unions because they were employing nonunion people at lower than union wages to do the work of unionized trades people. Future projects of this type will need to work in closer cooperation with the existing trade unions.

Conclusion
Many valuable lessons are to be learned from the experiences of Project S.U.E.D.E. This paper has attempted to analyze and evaluate many of the aspects of the S.U.E.D.E. project with the aim of adding to the existing body of knowledge needed to develop a skilled labor force prepared to meet the challenges of the "Solar Age." Some of the complicated issues raised by this project have been discussed: training design, sex roles, unions, political considerations, and solar employment potential. Project S.U.E.D.E. presents a model for existing and future solar training programs, and it deserves recognition and examination during the planning and implementation of solar training projects of the future. Solar exergy is a field filled with great expectations and high enthusiasm. Well executed solar training and demonstration projects play an important role in fulfilling the social and economic promises held out to us by the application of solar technology.

12.4

"AN ASSOCIATE DEGREE CURRICULUM FOR SOLAR TECHNICIANS"

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Abstract:
A two-year associate degree curriculum has been developed to train solar technicians.

The SOLAR TECH program prepares a person to (1) apply knowledge of science and mathematics extensively and render direct technical assistance to scientists and engineers engaged in solar energy research and experimentation, (2) design, plan, supervise, and assist in installation of both simple and complex solar systems and solar control systems, (3) supervise, or carry out, the operation, maintenance, and repair of simple and complex solar systems and solar control systems, (4) design, plan, and estimate costs as a field representative or salesperson for a manufacturer or distributor of solar equipment, (5) prepare or interpret drawings and sketches and write specifications or procedures for work related to solar systems, and (6) work with an communicate with both the public and other employees regarding the entire field of solar energy.

The curriculum has national and international significance, and is being pilot tested and revised by an international consortium: Navarro College, Corsicana, Texas; Brevard Community College, Titusville, Florida; North Lake College in Dallas, Texas; Cerro Coso Community College, Ridgecrest, California; and, Malaspina College, Nanaimo, British Columbia. It is being translated into Spanish and pilot tested in five locations in Mexico through the *Secretaria de Asentamientos Humanos y Obras Publicas*.

The final curriculum package will consist of eleven instructor guides for the eleven solar courses in the curriculum, student-oriented material, laboratory exercises and projects, audio-visual aids, and course prerequisites. It will be supplemented with an implementation guide designed to help administrators answer questions on laboratory space, laboratory equipment, instructor requirements, student profiles, investment expenditures, and other variables necessary to consider before adopting or adapting this curriculum to other schools and situations.

12.5

ENERGY EDUCATION AND THE ENVIRONMENTAL CONTROL TECHNOLOGY

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Abstract:
With varying degrees of awareness the Environmental Control Technology Program at New York City Technical College has been involved in Energy Education for well over 10 years. The program covers refrigeration, heating, ventilation, air conditioning, energy conservation and with lesser emphasis on solar, acoustics, lighting, fire protection, plumbing and electricity systems of buildings.

The educational strategy is the creation of a curriculum dealing with the design and maintenance of the environment within a building or process. It is most closely related to the economy and the requirement of the professions, trades, and business real estate communities to whom we provide a corp of trained personnel.

The maintenance of the man-made environment is achieved with the continuous expenditure of energy:
in heating by combustion of fuel, electric power, solar or alternate energy sources. Refrigeration for process or air conditioning works on the vapor compression cycle which requires a prime mover or the absorption cycle which needs some source of heat input.

In brief the curriculum is interwoven with energy considerations and decisions. Exactly how the Environmental Control Technology program deals with energy education in its credit based curriculum and its numerous Continuing Education endeavors will be described.

SESSION 13: TEACHER TRAINING

13.1

ENERGY EDUCATION IN GLOBAL STUDIES

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Energy education in global studies
Development of an interdisciplinary course involves problems not ordinarily encountered in curriculum development. In the case of Global Studies there is an additional difficulty; there is no agreed upon definiton of what constitutes a program of Global Studies. This presents a problem and an opportunity. A problem because of the danger of developing a fuzzy program without focus. An opportunity because one has the freedom to make value judgements concerning goals, content and evaluative procedures.

For our purposes, Global Studies is a course in which students explore the cultural, political, ethical, sociological, psychological, and technological factors affecting our views of global problems in the areas of resources, population, environment and economics. Students are helped, through problem solving processes, to develop an awareness of how these global concerns may be approached and resolved. In a nation such as the United States it is important to help students understand that the wealth and power accumulated by the developed countries imposes great obligations.

Several years ago the writers team taught some chemistry classes. Topics related to the environment, energy and population were intesrated into the chemistry course. As a result of this experience a Science and Society course was proposed. Sufficient student interest was not developed and the course was not taught. In the 1979-1980 school year Robert Sherburne, Language Department Chairman at Cazenovia, became interested in Global Education. Since many of the concerns explored in Global Education were also included in the Science and Society proposal, it was decided that the three teachers would develop an interdisciplinary course in Global Studies.

During the summer of 1980, Sherburne, Fredericks and FitzGibbons developed the Global Studies course. It was offered the following school year. The class included students in grades nine through twelve. Student evaluations of the program ranged from good to excellent. A fifteen hour workshop for teachers in the Cazenovia Central School District was conducted during the Spring of 1981. Nearly twenty-five percent of the teachers from most grade levels and subject areas participated. They indicated a great interest in Global Education and the intention to implement the concepts developed during the workshops in their classrooms. Many of the teachers, especially at the elementary level, included activities related to energy education. The goals and objectives of the Cazenovia Global Studies course are outlined below.[1]

Goals and objectives
I. The Individual's Involvement in the World System
Students should acquire the ability to:

A. Perceive themselves and all other individuals as members of a single species of life — a species whose members share: a common biological status, a common way of adapting to the natural environment, a common set of biological and psychological needs, common existential concerns and common social problems;
B. Perceive themselves and all humans as part of the earth's biosphere;
C. See how each person and the groups to which that person belongs are participants in the world's socio-cultural system;
D. Perceive that people at all levels of social organization — from the individual to the whole society — are both "cultural borrowers" and "cultural depositors"; they both draw from and contribute to a "global bank of human culture" that has been and continues to be fed by contributions from all peoples, in all geographical regions and in all periods of history;
E. Perceive that people have different perceptions, beliefs and attitudes about the world system and its components.

II. Making Decisions
Students should acquire the ability to:

A. Make "creative" personal decisions regarding their own lifestyles, in adjusting to "imposed and uncontrollable" changes;
B. Perceive and identify the transnational consequences of their personal decisions and of the collective decisions of the groups to which they belong;
C. "Take into consideration" the interests of others when making decisions with transnational consequences;
D. Perceive and identify long-term consequences of individual and collective decisions;
E. "Take into active consideration" the interests of future generations; when making personal and collective decisions.

III. Making Judgments
Students should acquire the ability to:

A. Perceive the choices confronting individuals, communities, nations and the human species, with respect to major world problems;
B. Obtain and process information analytically and to use reflective moral reasoning when making judgments about world problems;
C. Identify, describe and analyze their own judgments about world problems;
D. Perceive that human experience, earlier and elsewhere, may possibly be more useful for dealing with contemporary problems than beliefs dominant today;
E. Perceive the world system in a systematic manner;
F. Analyze, evaluate and create models of alternative futures;
G. Analyze controversy surrounding an issue, problem or policy.

A topical outline of the course content follows:

I. Problem Solving
II Factors
   A. Culture
   B. Politics
   C. Ethics and Religion
   D. Technology
III Population
IV Resources
   A. Food
   B. Energy
   C. Other
V. Environment
   A. Physical
   B. Biological
   C. Human
VI. Economics
VII. The Future
VIII. Intensive Personal Research

One of the first activities done in the course is called "The World in a Room."[3] Each student represents an appropriate fraction of the world's population. They are then divided into groups representing the population of the several continents. Based on 1977 statistics, in a class of 42 students each student would represent 100 million people. Twenty students, representing the population of Asia are sent to the center of the room; nine students representing the population of Europe (including European USSR) are sent to one corner; eight students representing the population of Africa and the Middle East are sent to another corner; three students representing the population of Latin American are sent to the third corner; and two students representing the population of North America are sent to the remaining corner.

Cookies or poker chips are used to represent energy use. According to the 1977 statistics used as the basis for this activity, the total world energy use was 220 milliquads. A scale of one chip per milliquad is used. Each group of students is given a number of cookies or chips according to the energy usage of the geographic unit represented. Asia received 35 chips or 1.75 chips per student. Europe receives 40 chips or 3.89 per student. Africa and the Middle East receive 28 chips or 3.5 per student. Latin America receives 24 chips or 6 per student. North America receives 93 chips or 46.5 per student. We have found that dumping the 93 chips in front of the two students representing North America has a much more profound impact on students and adults than any chart or graph we could devise. Similar procedures may be used to demonstrate the production and consumption of any resource for which statistics are available. Of course, the numbers must be adjusted according to the size of the class. This activity may be extended by extrapolation. Students from another class can be invited in to represent population growth. Increased energy use may be represented by additional cookies. It is an impressive way of teaching the nature of exponential growth.

This past year, the energy block in the course occupied about 15 class periods. The activities used vary in student participation from active role playing simulations to personal or group research on a specific energy topic. A large proportion of the initial activities, which are designed to assess the incoming knowledge and attitudes of the students, are taken from the B.S.C.S. Energy & Society[4] materials. The materials we used from this packet provide a good starting point upon which to build an energy unit.

The initial activity is a knowledge/attitude inventory which is administered to all students. The results of the survey are tabulated and presented to the class. This serves two functions: 1) It gives a barometer of where the class stands in terms of knowledge and attitudes towards energy and 2) it provides a nice jumping-off point for further discussion of various issues/topics addressed in the survey. A follow up to the activity involves a student discussion of one or two of the controversial items in the survey, i.e. items for which there was no clear concensus. Students are asked to clarify their positions and cite relevant factual information to justify their positions. At this point students often find out that their "feelings" about energy are not necessarily based of valid information. Another outcome of this activity is that students begin to come to the realization that there are often not any simple answers to energy problems, particularly when personal attitudes and personal freedom are involved.

The inventory indicated a considerable lack of knowledge on the part of the students of information concerning energy and concepts that govern its utilization. We used a number of films and video tapes to present this information to the class, and asked students to take notes in their journals. Another activity which helped to give the students more background information invovled having groups of students present reports on a particular type of energy technology. They were to gather as much current information on their particular resource in the following areas:

Physical Laws soverning the use of this energy source
Political Laws or policies affecting use of the energy source
Environmental Impact
Economics, Public and Private
Public Attitudes
Health and Safety
Design and Technology

One of the most neglected areas of energy education is showing the total energy cost of objects, not just their direct energy use. The B.S.C.S. materials include a good activity to demonstrate this called "Back to the Source." Students view a film loop which traces a phonograph record from its disposal, backward through distribution, manufacturing, and eventually back to the original source of the material for the record. Through discussion, students try to pinpoint all the energy consumed during the lifetime of the record. The students are then asked to produce a diagram showing all the energy inputs invovled in the producting and. distribution and use of a common household item. After completing this activity, students have a better idea of the indirect energy costs found in our complex lifestyles.

Other activities were included in the unit to help student's set a better picture of their own personal energy consumption patterns. A personal energy budget was prepared and then compared to energy consumption figures for individuals in other parts of the world. Next year we will be incorporating some of the activities from the NSTA's Energy Enriched Curriculum,[4] in particular those in the "Energy in the Global Marketplace" module.

One of the most popular parts of the unit was the use of simulation games. Each of the simulations emphasized slightly different aspects of the energy picture. Those that were used included:

"Energy Quest" Weldon Productions Inc. Columbia, SC
"The Energy Management Game" B.S.C.S.
"Energy X" Ideal School Supply Co., Oaklaum, IL
"The Energy Environment Game" Edison Electric Institute, Washington, DC

Students were asked to write a paragraph or two to describe those things that they learned from using the simulations. These thoughts were shared with the class. The simulation gave students a chance to make decisions to solve energy problems and see the effect of their actions. Our experience during the first year indicated the need to expand the amount of time spent on this topic. We have expanded this unit by ten days and are incorporating more activities in which students can further explore the world wide differences in energy resources and consumption.

The last unit, The Future, required class members to bring together all the parts of the course. The student's discussions during this segment and their individual research projects (the final 5 weeks of the course) gave evidence of an understanding that energy considerations are an integral part of many of the problems facing us today.

In the Global Studies course and specifically in the energy unit, our aim is not to provide students with answers. Our purpose is to help student's identify those factors which affect global issues and to help them gain the problem solving skills and information necessary to think globally and act locally.

References

[1] (adapted from David C. King, Margaret S. Branson and Larry E. Condon, *Education for a World in Change: A Working Handbook for Global Perspectives*, Intercom No. 84/85, (c) Center for Global Perspectives of the New York Friends Group, Inc.)

[2] Smith, Gary R: *Cultural Sight and Insight* pp. 15-18 Global Perspectives in Education, Inc., New York 1979

[3] *Energy and Society: Investigations in Decision Making* (c) biological Sciences Curriculum Study, 1977

[4] "Energy in the Global Market Place" *Energy Enrichment Curriculum*, U.S. Dept. of Energy, Oak Ridge, Tenn. 1978.

13.2

SUMMER WORKSHOP FOR ENERGY EDUCATION TEACHERS IN TEXAS

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Sponsored by:
The University of Texas at Austin
Science Education Center

Introduction

The Summer Workshop for Energy Education Teachers in Texas (SWEET-TX) is designed to improve Texas Community College Teachers' understanding of energy issues and concepts. Science teachers, with an understanding of these issues and concepts are more able to educate their students and community about energy related problems and issues. The objectives for the workshops are for teachers to be able to:

A. Analyze complex energy related issues and explain the historical, cultural, political, economic, and scientific dimensions of the problems.
B. Describe examples of renewable resources and methods of energy conservation.
C. Describe specific environmental and safety aspects of energy production.
D. Describe a model for energy production and utilization emphasizing the special place of electricity in using energy, including the use of coal, nuclear, and solar systems for power generation.
E. Describe projected shortages in oil and natural gas, and means for reducing the national demand for nonrenewable energy resources.
F. Develop a community energy education curriculum and a plan for its implementation in their community.
G. Maintain contact and communication with the training institution and experts in energy related topics.

The scope of this project includes Texas college science teachers. Participation is limited to teachers in Community Colleges, private two and four year colleges, small four year public colleges, and other involved in continuing adult education efforts. The Summer Workshop is offered the second two weeks of June.

Scope of the workshop

Community Colleges have emerged during the past two decades as institutions of diversity, meeting the needs of individuals 17-18 years of age with varying abilities, goals, and experiences. "Community" colleges have replaced "Junior" colleges through their focus on providing basic education courses, vocational training programs, and credit and non-credit continuing education courses, in addition to the additional junior college focus of two-year academic transfer courses. Many institutions have adopted institutional mission statements and program guidelines which stress their commitment to being responsive to the needs of the local population. Also through the efforts of the national governing body of community colleges, the American Association of Community and Junior Colleges, they have made public their commitment to lifelong learning to foster adult development and self sufficiency.

The schools which comprise the Texas community college system are known nationally for their innovative program efforts and continuing education outreach efforts. Statistics reported in October 1979 to the American Association of Community and Junior

Colleges indicated tha the total number of individuals who participated in community education programs in the state, 289,827, surpasses the total number of full and part time academic and vocational students enrolled during the same period, 262,236. Texas is one of the five states in the nation which served over 250,000 individuals during the reporting period.

The issues of meeting the world's energy demands and its environmental consequences is a paramount concern for today's citizen. The global politics of energy influence world events as evidenced in daily news headlines. The economic costs of energy utilization and shortages of available energy are central concerns in U.S. households. Texas citizens have a unique interest in energy issues because Texas is a center of oil production and industrial technology. A large part of the Texas economy is dependent upon energy related business.

The U.S. requires an informed and scientifically literate citizenry. In a democratic society, the success of the political system at responding and planning for the society's needs is predicated on the ability of the individual citizens to be informed participants. Every American has many opportunities to influence the solution of U.S. energy problems through participation as 1) a voter in federal, state and local elections, 2) an individual providing input to political representatives about individual concerns, and 3) a consumer making daily decisions about energy utilization.

In order to meet the need of developing an energy informed and scientifically literate U.S. citizenry, the SWEET-TX project will train a cadre of competent science teachers in energy education to operate within the already established community education system. The fact that Texas has one of the most prominent community college education systems in the U.S. facilitates the implementation of a community college education program. The miltiplier effect is included in the program design of this project. Large numbers of citizens can be reached efficiently and economically by training a cadre of faculty to in turn educate the community citizens.

The SWEET-TX project comes at an opportune time. Current concerns of the Texas citizens include energy issues. Public controversy surrounds the South Texas Nuclear Project. Enviornmental concerns about energy production were provoked by the Gulf of Campeche Oil Spill in the Fall of 1979. Current community and state interest is evidenced by the numerous energy/environmental organizations and services such as: the Austin City Renewable Energy Resources Commission, Texas Energy Extension Service, Texas Solar Energy Society, Phogg Foundation, Austin Energy Initiative, Science for the People, Texas ACORN, and Texas Mobilization for Survival. During October 4-11, 1980, a Texas Solar Action Week emphasized Texas' concern for energy issues and included a SunFest exhibit in Austin where Texas energy/environmental concerns organizations provided information to the public. Texas citizens are exhibiting signs of concern with energy issues by becoming involved in these activities. This involvement should enhance the receptivity of the community to the SWEET-TX project's energy education efforts. The time of energy education efforts in Texas is now, while the citizens are themselves establishing the need.

Workshop Design

The course content is introduced the first day by presenting an organizing energy conceptual scheme. Concept mapping and webbing are used to assist the participants in establishing the relationships between the various energy related concepts. These organizing concepts include but are not limited to: 1) Energy Supply and Demand models, 2) Nonrenewable resources, 3) Energy Conservation 4) Energy/Environmental effects, 5) Energy Resources, and 6) Energy Utilization. This interrelated conceptual scheme developed in the presentation by the participants will be used as an advanced organizer to facilitate the assimilation of the content from the presentations into a coherent energy understanding.

The topics to be included in the instruction for SWEET-TX emphasize: 1) Energy related issues and content, 2) Activities, resources, sources of information, and methods of instruction for energy education, and 3) Curriculum development and implementation models for Community Energy Education Programs. The topics are presented by lecture-discussion, laboratory activities, and field trips. The course format for the program is lecture presentations of energy related topics in the morning and laboratory/curriculum development activities in the afternoon. The course is presented in two full weeks of instruction. The participants are involved in 44 hours of direct instruction, 8 hours of field trip activities, and 28 hours of laboratory activities.

The energy topics are presented by experts in the scientific areas. These experts include University scientists and engineers, economists, political scientists, and representatives of the energy industry. Additional state and local representatives of citizen groups concerned about energy/environmental issues are invited to provide information about their organization and share their views during the "Energy Fair." The purpose for inviting scientists, social scientists, engineers, industrial representatives, and concerned citizens as presenters is to encourage a broad range of views and opinions about energy/environmental issues and to establish a communication between the participants and the experts in energy related topics.

The topics in this workshop focus on issues especially relevant to Texas citizens. There are presentations addressing Texas energy policies and energy education systems. Nuclear energy production, nuclear fusion, lignite fueled plants, and biomass energy production are current projects in Texas. Including state and local community concern groups in panels, exhibits, and presentations increases the relevance of the workshop to Texas concerns.

The topics for the course are covered using a variety of methods and approaches. They are selected to provide information relevant to the objectives for the course. The energy content of the course is introduced first by an expert in the specific area of knowledge through the lecture/discussion approach. The guest instructors use a variety of teaching modalities, including various multimedia and activity oriented methods. A panel discussion is used to enhance the exchange of viewpoints about nuclear power and its impact. An energy-environmental simulator is used to provide the participants with an opportunity to interact with and apply their knowledge of energy and environmental parameters. The field trips to the university energy facilities are used to motivate interest and increase knowledge about current production and research about future production of energy.

The afternoon energy curriculum laboratory sections are used to provide participants opportunities to apply their new knowledge to the development of an energy educational curriculum plan for their own situation. Instruction is provided about available resources for materials and services, and sources of information. DOE, NSF, and NSTA energy education materials are made available to all participants in the laboratory activities. The participants are provided training and instruction in energy education curriculum development and implementation. Materials and support services are provided to assist the participants in selecting and organizing their own curriculum. These materials are located in the Energy Education Curriculum Library in the Science Education Center. The library contains a large collection of K-12 curriculum materials, secondary and higher education energy related textbooks and readings, and assorted published materials from energy related corporations and the government. The participants are divided into teams to develop course syllabi and implement plans for common teaching situations. The teams are identified and formed from information obtained during the application procedure. Individuals describe their teaching situation and specify their 1) 3 hour credit course plans, 2) integration into science course plans, and 3) short community presentation plans. The teams make presentations of their curriculum plans during the last day of the course.

During the year following the summer workshop, participants have additional opportunities to share materials and ideas about energy education and to interact with university faculty. The project staff and co-directors are available for consultation throughout the year. Copies of the materials developed by the teams are duplicated and sent to all participants. There are two additional meetings during the following year for the participants to share materials, ideas, and report progress on their implementation efforts. The first meeting is held in conjunction with the Fall Texas Conference for the Advancement of Science Teaching. The participants report on the implementation and progress of their efforts during this meeting. The second meeting is during the Spring meeting of the Texas Academy of Science. This meeting is used to report an evaluation of the first semester of use of the energy education plans. The participants and their institutions are responsible for providing their own support for these follow-up meetings.

The participants' utilization of the energy knowledge in community education is evaluated for one year following the project. The Concerns Based Adoption Model (CBAM) for investigating innovation implementation is used in this study (Hall, 1977). The Stages of Concerns and Levels of Use Instruments are used to investigate the changes of the participants energy education programs. Data are gathered with these instruments during the workshop and during the year following the workshop. A questionnaire is used to gather descriptive information about each participant's program configuration. In November and March of the year following the workshop, each participant will be invited to attend and present their program to the group and to discuss and exchange ideas. Additional data will be gathered during these meetings to determine the success of the community education program. A thorough analysis of the evaluation data is provided to all participants and the funding agency. This report is a comprehensive evaluation of the success to which the SWEET-TX project meets the predetermined goals.

Evaluation Methodology

A thorough evaluation of the effects of the program is an important component of the SWEET-TX project. A pretest/posttest design is used to investigate the effect of the instruction on the energy education knowledge and attitudes of the participants. The National Assessment of Educational Progress Energy assessments for young adults (NAEP, 1979)* was used to measure energy achievement and attitude. The instrument has 76 items relating to feelings and concerns and 70 items for the cognitive domain.

Evaluation forms are used to obtain information about the ability of the workshop activities to satisfy the needs of the participants. The DOE participant evaluation form is a 26 item instruction survey which includes questions on demographic data about the participants and perceptions about the success of the workshop. The Daily Presentation/Activity Evaluation form is provided to participants for recording evaluations of each presentation and activity during the workshop. The combination of the two participant surveys provide information which is used to evaluate the workshop activities.

Results

The 21 participants involved in the SWEET-TX project have teaching experience at all levels ranging from elementary to higher education. The mean number of years of teaching experience in community colleges is 6.86. Community college teaching is the present employment status for 67% of the participants. The participants specialized in a variety of science and social science disciplines. Science accounts for 76% of the participant major fields and Biology is the largest at 38%. There is under representation among minorities and women with 76% of the participants being white males.

The results from administering the DOE Participant Evaluation Form are very positive. The usefulness of the workshop and overall reaction of the participants to the workshop are rated very high.
The participants expect to enroll a mean of 139 students this year in energy related courses. They feel that the mix of participants was advantageous to the learning. Lecture is the activity found most motivating and most applicable to their teaching. Ninety-five percent of the participants intend to introduce energy topics into their teaching. A follow-up session is desired by 75 percent of the participants.

The participants scored significantly higher on the NAEP achievement posttest than they did on the pretest. Their mean score for the pretest was 49.57 and for the posttest was 58.71. The participants scored significantly different on 47% of the NAEP attitude posttest items when compared to pretest responses on the same items. A Chi square test was used to determine the significance of the difference among frequency distributions for items from pretest to posttest. The overall trend of the attitude change for these items was for greater concern and more positive attitudes about energy problems.

Conclusion

Two week summer workshops on energy topics for college teachers can be effective. The content knowledge and attitudes is improved by a carefully structured intensive educational experience.

These college teachers can in turn return to their communities and institutions and implement local energy education programs. Those teachers can educate on the average 150 students each year. Their students can be local leaders, young adults pursuing energy related careers, or public school teachers.

The central goal of this project is to increase the local citizen's awareness and knowledge of energy issues. The SWEET-TX project capitalizes on the strengths of Texas' excellent community education program by selecting practicing community college educators as the local energy education leaders. The likelihood of success of this project at achieving the goal of increased citizen energy awareness is greatly enhanced by the selection of a target population already dedicated toward the goal of developing a scientifically literate community citizenry.

The participants were selected for their likelihood of creating change in their community's energy awareness. They are committed to developing their own energy education plan for their own community. They are encouraged to train other community leaders, educators, and concerned citizens to in turn educate others within the community, which greatly increases the number of citizens impacted (Multiplier effect!). They select the best methods to reach the citizens in their locale, including creating credit courses in energy education in their community colleges, integrating energy concepts into their existing courses, serving as presenter and consultant to local citizen groups, and developing a Community Energy Service Center. These community college teachers are the key "change agents" for promoting an increased citizen awareness of energy issues.

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13.3

Energy Education Workshop for Teachers: K - Junior High

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Introduction
This paper reports on a three-day inservice energy education workshop for elementary and junior high teachers from the greater Lafayette, Indiana area schools. The following areas will be discussed:

I. Needs Assessment
II. Planning
  A. Recruitment
  B. Program
  C. Speakers
  D. Materials
III. Funding
IV. Implementation
V. Evaluation
VI. Dissemination
VII. Conclusions

Needs Assessment
The Indiana Council for Economic Education was contacted by the Lafayette, Indiana School Corporation concerning an energy education inservice workshop. Teachers had requested opportunities to increase their knowledge of energy-related subject matter and energy-related education materials for classroom use. As a result of this contact the ICEE requested and received letters from the Lafayette School Corporation and other local public and nonpublic school corporations supporting the desire for an inservice energy-related workshop for greater Lafayette area teachers.

The Indiana Council for Economic Education was selected to conduct an energy education workshop because of its past experience in sponsoring inservice programs, summer workshops, institutes, and seminars for teachers and other community leaders. The ICEE is located at Purdue University, West Lafayette, and is sponsored by the Krannert Graduate School of Management and the Continuing Education Administration of Purdue University. The director and associate director of the ICEE have faculty appointments in the Krannert Graduate School of Management with the specific responsibilities of providing economic education experiences to groups on campus and off campus. Unique features of ICEE workshops are released time for participating teachers, graduate credit incentives, and materials development for personal use.

The Lafayette School Corporation Director of State/Federal Projects met with the associate director of the ICEE to plan an energy eudcation workshop after the public and nonpublic administrators and teachers of the greater Lafayette area were informed of the possibility of this inservice training. A telephone survey of selected K-9 teachers determined that a sufficient number were interested in attending such a workshop. Specific teachers were involved informally in planning and implementing the workshop.

Recruitment
A brochure describing the workshop and an application form was distributed to elementary and junior high teachers in the target area. The brochure contained a rationale for the workshop as follows:

> Energy, its use and abuse, is of paramount concern to U.S. citizens who are being constantly bombarded with admonishments to turn down the thermostat and turn off the lights. There is a wide diversity of opinion about whether an energy crisis actually exists, but all agree that energy issues are closely related to both our national pleasures and our national problems.
> In response to this national concern and confusion regarding energy, U.S. public schools are integrating aspects of energy education into their curricula. The economic tools for simple market analysis and the instructional materials provided by workshop personnel will enhance participants' abilities to deal effectively with energy questions in the classroom. The workshop will focus on a broad spectrum of information regarding energy resources, alternatives to current technologies, and environmental and economic aspects of the energy problem, and appropriate teaching practices.

The brochure contained information on location, time, and the Indiana Council for Economic Education. A schedule of activities and an application form were included.

Program
Speakers were selected by the associate director of the ICEE for their expertise in various energy fields. On day one in the Fall of 1979, a professor of history from Purdue University spoke on "Energy Crises in Retrospect." The goal of that session was that particpants would be able to cite instances of historical energy crisis. In the afternoon of day one, a Purdue University professor of education and geosciences spoke on "The Fossel Fuels Dilemma." Following that address, participants were able to chart the past and project the use of fossel fuels and list the advantages and disadvantages of using fossel fuels. A professor of economics at Purdue University-Calumet spoke on energy "Alternative Sources," and the director of the Indiana Council for Economic Education spoke on "The Economics of the Energy Problem." The day concluded with concurrent sessions for elementary and junior high teachers. A fifth grade teacher from the Lafayette School Corporation worked with elementary teachers on "Integration of Energy Education in Class Situations." An eighth grade science teacher from the Lafayette School Corporation helped participants identify specific instances of elementary and junior high energy education in a session entitled "Integration of Energy Education in the Junior High Curriculum."

Day two began with a Purdue University professor of economics addressing "The Political Impact on the Energy Question." This session was followed by a professor of agricultural economics speaking on "Energy From Biomass." The afternoon of day two was devoted to a study of the Indiana Department of Public Instruction *Energy Education Curriculum Project.* The day concluded with participants in consultation with the workshop staff, planning their individual projects for integrating energy economics into their classrooms. After teachers had integrated the energy education materials they developed following days one and two of the workshop into their classroom curricula, they reassembled for one day in the spring of 1980. After a beginning session on "Energy—Future and Current Policies," teachers reported on their classroom projects. The afternoon program was conducted by persons representing additional resources for future energy education. The curriculum directors of Lafayette School Corporation spoke on the emphasis on energy education by the school corporation. The director of the TRIAD Teaching Center explained what materials and facilities were available to teachers. The associate director of the Indiana Council for Economic Education distributed materials and gave participants information on energy education sources. The program closed with participants summarizing the strengths and weaknesses of the workshop and offering suggestions for maintaining an energy education program in the schools. Participants were post-tested with an objective instrument and an attitudinal instrument.

Speakers

Speakers were from the following areas:

1. History with a background of the history of technology, history of science, history of thought, and publications on the history of political economy.

2. Geosciences Education, author of college textbooks, director of energy education projects, and national foundation grants.

3. Department of Agricultural Economics with publications and textbooks concerning energy resources and government policy.

4. Elementary and Junior High teachers whose workshop responsibilities were to demonstrate how energy-related subject matter can be taught in elementary and junior high schools and to work with participants on their individual projects.

Materials

Teachers indicated their need for energy education materials on the survey carried out prior to the energy education workshop. In response to that need, commercial and noncommercial materials were assembled and made available to teachers for use in and after the workshop. The following materials were distributed to participants:

Eleven materials from U.S. Department of Energy
Sixteen materials from AMOCO, Standard Oil Company
Twenty-one materials from various other sources

In addition materials were correlated to specific sessions throughout the workshop. For instance *Energy For Man* — a film strip which traces the increase in man's use of energy since 1850— was made available with the session on "Energy Crises in Retrospect." An energy education mini-course developed at Purdue University was distributed with "The Fossel Fuels Dilemma." A film, "Energy: The Fuels and Man," was made available from National Geographic Educational Services. Teachers used the materials which they recieved and the materials which were used with the workshop sessions in preparing the materials for their classroom.

Funding

The Indiana Council for Economic Education submitted a proposal to the U.S. Department of Energy, Elementary Teacher Inservice Energy Education, in the amount of $8,500 to cover expenses of the proposed three-day energy education workshop. The monies were budgeted to cover a portion of the workshop director's salary, a stipend to visiting speakers, clerical help, and instructional materials. The instructional materials were ordered in duplicate, and, at the conclusion of the workshop, one copy was retained by the Indiana Council for Economic Education and one copy was placed in the library of the Lafayette School Corporation for continued use by teachers.

The Indiana Council for Economic Education received an $8,500 grant from the U.S. Department of Energy to conduct the workshop. One graduate credit was awarded teachers fulfilling workshop requirements by Purdue University.

Implementation

Seventeen teachers completed the energy education workshop. They met from 8:00 to 3:30 Ocotber 25 and 28, 1979, and April 16, 1980. During the first two days of the workshop, teachers received energy education content and wrote lesson plans to be used in their classroom before the third day of the workshop. Classroom activities included student-prepared materials for a seventh grade media fair, an energy conservation day involving an entire elementary school, a survey of transportation modes by third graders, an energy awareness unit designed to help families save a gallon of gas a week, a fifth grade science unit focused on strategies for changing people's behavior into an energy conservation mode, a poster contest, building a solar oven, conducting a home energy audit, and others. On the third day of the workshop, participants reported on the implementation of their units in their classroom. Workshop instructors suggested modifications of units for further use. Units were duplicated so that each participant would have a copy of each unit produced during the workshop. Reports on media coverage and plans for further use of the teacher-created materials were shared.

Evaluation

Teachers were pre- and post-tested with both cognitive and attitudinal instruments related to energy. The pre-test mean on the cognitive test was 17.5 with a range of 6-24 and the post-test mean was 20.6 with a range of 15 - 24. Test items were written by the workshop director and speakers. Table I shows change in attitudes related to energy.

The DOE Faculty Development program was evaluated by the Labor and Policy Studies Program, Manpower Education Research and Training Division, Oakridge Associated Universities, Oakridge, Tennessee in September, 1980. The following is taken from pages 14 and 15 of their report:

Overall Reaction to the Workshop

The reaction to the workshops was very positive. An overwhelming majority of participants (97 percent) reported that they would recommend the workshop to a friend, whereas only 2 percent would not. Another 1 percent said that they would recommend it only under specific conditions. Many of the negative responses were in reaction to one workshop which, as responses to the open-ended questions in the survey indicated, was too technical for the attending teachers. In response to the request "Give your overall reaction to the workshop," participants characterized the program as being between extremely motivating (category 1 on a 5-point scale) and motivating (category 2). The results....show that engineering teachers were less impressed by the workshops than were the average participants, whereas home economics, social science instructors, and sixth grade teachers were more impressed. Responses varying from the average seemed to be related to the degree of difficulty the respondents experienced in handling the materials presented in the workshops.

The pattern of responses to the open-ended questions tends to confirm the conclusion that the overall reaction of most participants to the workshops was favorable. While few individual activities offered in the workshops were mentioned here as being particularly beneficial, many participants characterzied the program as interesting and stimulating.

Dissemination
The units developed by teachers in the workshop were made available to every teacher attending the workshop. A unit developed by two teachers was entered in the state-wide aware program for the teaching of economics in Indiana and was awarded first place in 1980. As a result the teachers presented their project at the annual meeting of the Indiana State Teachers Association. The newsletter of the Indiana Council for Economic Education carried excerpts from the teaching units. The newsletter is made available to teachers and administrators throughout Indiana and to Economic Education Centers and Council Directors in 49 states.

The following is from page 15 of the above-cited evaluation by the Labor and Policy Studies Program, Oakridge, Tennessee:

> Intended Future Implementation
> Participants were also asked to describe how they intend to use the new energy knowledge gained from workshops. (The)...inclusion in lectures and handouts will be the most commonly used means of applying the knowledge. Teachers in the sample using these approaches will reach a minimum of 90,000 and 83,000 students respectively. Two hundred and eight respondents expected to incorporate energy information into student research projects. Not only will this new information be disseminated in classrooms, but at least 46,000 students will be involved in environmental or conservation projects; and 64,000 will discover and experience in the laboratory. The estimated number of students reached, should be approximately doubled when all teachers attending the workshops, and not just respondents, are considered.

Conclusions
The workshop objectives were to provide teachers with the analytical tools and instructional materials needed to teach energy education effectively in the classroom. As a result of the workshop, participants taught at lease one energy-related unit to their students, had access to other classroom-tested units on energy, and exchanged teaching experience and materials with other teachers at their grade levels. In addition, teachers from throughout Indiana were exposed to units prepared by greater Lafayette area school teachers at the annual meeting of the Indiana State Teachers Association.

13.4

"Planning Successful Inservice TRAINING in Energy EDUCATION"

Dr. Mary Alice Wilson
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Mr. Shaun Bresnahan
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Mr. David Rainaud
Math teacher, Belchertown Junior-Senior High School

Abstract
For the past two years, the Inservice Program of the Hampshire Educational Collaborative has been sponsoring inservice programs in energy education.* Based on our experience in these courses, and in courses in a number of other areas, we have developed the following criteria for successful integration of energy education into the classroom:

1) Administrative support of energy education activities
2) Teacher participation in planning of the inservice course
3) Continuous evaluation of progress of the course
4) Concentration on use of local resources and resource people that are readily and inexpensively available to school systems after course concludes
5) Focus during course on inquiry based, experimental learning for teachers (and students)
6) Inclusion of mechanisms on conservation and alternative energy through the use of inexpensive energy models
7) Commitment to participants after course ends through a monthly support group, newsletter or other communication mechanism

We have developed a number of strategies for achieving these seven components including a computerized resource retrieval system (written in BASIC for the Apple II), and mechanisms for planning, evaluating and continuing support to course participants, and a series of simple alternative models.

The presentation will include flow charts, slides, and panel discussion of strategies for insuring that energy education will be integrated into the elementary and secondary curriculum.

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13.5

ENERGY — A VIEWPOINT FOR TODAY AND TOMORROW: AN ENERGY EDUCATION COURSE FOR TEACHERS

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Abstract
Energy — A Viewpoint for Today and Tomorrow has been offered for the past 3 years to teachers in the Mojave Desert region of the Southern California Edison Company. Since the number of teachers in this region is limited, the course was designed to serve the needs

of classroom teachers from the primary through secondary levels. This presentation will include a discussion of the course structure, and pedagogy, a review of some of the participant developed projects and materials and an overview of the participants evaluation of the course.

Support for these courses comes from the Educational Services Department of the Southern California Edison Company. A brief discussion concerning the academic/industrial interface aspect of this project will be presented.

SESSION 14: CURRICULA AND ASSESSMENT

14.1

DEVELOPMENT OF 10TH GRADE CURRICULUM MATERIALS
ON ENERGY FOR NATIONWIDE USE

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Abstract
The topics of energy crisis, alternate energy sources, and energy conservation measures are integrated into the 10th grade government physics textbook, *Physics in Your Environment*, developed by the University of Philippines Science Education Center.
Main entry points are the lessons on the energy conservation law and nuclear power plant. The energy topics are presented in a comic strip interspersed with questions for students.
The Center also developed supplementary modules on a solar cooker and solar crop dryer made of low-cost local material. Besides teaching science content and relating science to national concerns, the modules teach design skills.
Activity-oriented teaching units on energy for grade 10 have also been prepared by the Ministries of Education and Culture and of Energy. Objectives and concepts of the units are articulated for grades 7-10.

Energy education in relation to the energy problem is not well-established in the Philippine school system. There is a need for articulation and empirical placement of energy concepts and values for grades K-12. Energy curriculum materials need to be developed for each grade level that are responsive to fast-changing energy developments. That provide teachers with skills to organize and simplify increasing energy data and that result in students' greater understanding of concepts underlying indigeneous energy devices and resources.

Energy education in the school system
The Philippines with a population of 48 million and gross national product (current market price) of US $35 billion used 91.9 million barrels-of-oil equivalent of energy in 1979, 91.4% of which is oil. [1,2] Imported oil was 81.4% while domestic oil was only 10%. The energy requirements are projected to increase by 100% ten years hence. By then, domestic oil is to have increased by 62%. Still, imported oil will constitute 31% of the 1989 energy requirements.

These facts and projections and the nonrenewability of oil resource are compelling reasons for having energy education programs in the country's school system. Integrating the energy issues into the curriculum will: (1) complement the government's intensive mass-media campaign for energy conservation, (2) enable students to study the economic, political, social and environmental facets of the energy problem, (3) enhance students' understanding of the science concepts and principles involved, and (4) prepare students for the developement or use of indegeneous renewable energy sources.
The Philippine energy situation is discussed in some local textbooks and taught by a number of teachers. However, this paper limits the discussion to energy curriculum materials developed for high school physics (grade 10) for nationwide use.

Energy in the government physics textbook
The topics of energy crisis, alternate energy sources, and energy conservation measures are integrated into the Grade 10 physics textbook, *Physics In Your Environment*, to accomplish one objective of relating physics to national concerns.[1]

The book was developed by the physis team headed by the author from the University of the Philippines Science Education Center, the national curriculum development center for science and mathematics. Part of the government textbook project, the book will be distributed free, one book for every two students, to public schools in June, 1982.

The development model for the lessons on energy follows that of the other lessons in the book.[3] There was preliminary evaluation which included assessment of students' entering competencies, teachers' perceptions of student needs, and existing school laboratory facilities. A small group of students was available for mini-tryout as the lessons were written by a team of physics teachers, physics educators and physicists. The formal tryout was conducted nationwide in 52 schools. Tryout feedback included the difficulty level, readability and appeal of the lessons. In revising the lessons, the energy data had to be updated for the final printing.

One unifying concept of the book is energy, reflected in the unit titles: Force and Energy, Waves: Carriers of Energy, Electrical Energy, and Energy of the Nucleus. The specific entry points of the energy topics in the book are the following lessons:

Lesson 1.2. Speed Up or Slow Down
5.2. Energy Conservation — How and Why
10.2. Mechanical to Electrical Energy
11.2. Electrical Energy to Heat and Light
12.3. A Visit to a Nuclear Power Station

Lessons 1.2, 10.2 and 11.2 do not deal as extensively with the energy problem as lessons 5.2 and 12.3. In lesson 1.2, students are told that gasoline is pumped to the vehicle engine when the accelerator pedal is pressed. The advice is given that driving at constant, moderate speed on a level road saves on gasoline.
Lesson 10.2 mentions the government's plan to build electric power stations that do not depend on oil. The reason cited is the effect of the increasing cost of oil on the country's industries and economy. The opeating principle of the geothermal hydroelectric and nuclear power plants is briefly discussed.

Lesson 11.2 exhorts students to conserve electrical energy for low electric bills to help reduce the nation's energy needs. Students are told that appliances with higher power convert electrical energy into other forms faster. They are taught how to read their electric bill and electric meter and compute the cost of electrical energy used at home. The heat and light given off by flourescent and incandescent lamps are also compared.
Lessons 5.2 and 12.3 present the energy situation in comic strips interspersed with questions to be answered by students. The comic strip format was well received by the tryout students.

In lesson 5.2, a discussion and activity on the energy conservation law precede the comic strip on the Philippine energy situation. The comic strip is a dialogue between a grade 10 student and his teacher. Here are some excerpts.

Student: Miss Cruz, why conserve energy when it's conserved as a law of nature? Also, as long as the sun shines, we have energy. So, why worry?
Teacher: The government's campaign is to conserve only certain forms and sources of energy. What we need to save are oil and coal needed for electricity, transportation and industries. We depend much on oil and its products like gasoline and cooking gas.
Student: But why save oil? As long as the sun shines, plants and animals grow, die and then decay, forming oil.
Teacher: But it takes millions of years for them to decay and form oil. We burn oil faster than it is formed.
Teacher: The government aims to buy less oil from other countries and depend more on our resources. So, it is looking for oil substitutes. (Alternate energy sources are briefly shown.)
Teacher: The government also encourages the industries to produce more for the same or less oil requirements.
Student: Should we not also use less often the things which need oil?
Teacher: You're correct. That's why the government sometimes limits the gasoline you buy. As a citizen, how else can you save on energy of oil?
Student: Let me think....
Question to the reader: Can you help Lino? List the ways by which you, as a citizen, can conserve energy of oil.

The comic strip in lesson 12.3 integrates an activity simulating fission and chain reaction using matchsticks and bottle caps. The students are cautioned about the limitations of the simulation.
This lesson on the nuclear power plant is significant in view of the recent controversy surrounding the only nuclear power plant in the country. Construction of the US $1.9 billion 620-megawatt plant was stopped in 1979 for more than a year. Public hearings were conducted to investigate the plant's safety. Notwithstanding the additional safeguards to be installed, some environmentalists are still opposed to nuclear energy as an alternate energy source.
The comic strip, through the conversation of two Grade 10 students and the engineer of the plant, presents the side of the government as well as the environmental implications of the plant. Uranium is mentioned as a much cheaper energy source, compared to oil and coal. The criteria for a nuclear plant site are listed. Nuclear accident, effect of waste heat on marine life and the problem of nuclear waste disposal are discussed.

The lessons in the textbook dealing with the energy problem relied heavily on data and manuals of the Ministry of Energy and the Philippine Atomic Energy Commission.

Enrichment lesson on energy
To supplement the government physics textbook, the physics team of the University of the Philippines Science Education Center is developing modules in several areas; one is on alternate energy sources. A specific area of interest is solar energy. The Philippines is blessed with abundant sunlight, averaging 2000 hours a year, with insolation of about 400 calories per square centimetre per day.

Modules on a box-type solar cooker and tent-type solar crop dryer have been written. [5 6] Development of a module on windmills for pumping water is ongoing. The development process of the modules is similar to that of the textbook except the formal tryout is confined to a school typical of the target group.

One primary objective of these modules is to translate the work of the scientist or technologist for studens' use, emphasizing the science concepts and skills involved. In cases where a device is the focus of study, the device is the vehicle for teaching the science concepts.

Selected devices are those made of low-cost locally available materials. Substitute materials are used to lower the cost of devices to an amount (about US 7-9) affordable by teachers and students for a class project.

In the solar cooker, for instance, plastic sheet is substituted for glass, carton boxes instead of wooden box, newspapers instead of fiberglass material, carbon paper instead of black paint. The only materials to be bought is 2 meters of plastic sheet costing about US $1: the rest can be brought by students. Needed masking tape and glue are school supplies. If most of the materials are bought including the mirror, the device costs about US $7.

The solar crop dryer costs a bit more. If bamboo is used instead of wood for the framework and can be obtained free, the only expense is about US $8.5 for 19 meters of plastic sheet for the table and full-scale models. Thumbtacks are used to fasten the plastic sheet to the bamboo frame.

Response of tryout students to the modules was enthusiastic. The students initially could not believe it was possible to boil eggs in the solar cooker. Tasting the hard-boiled eggs for the first time was a joy of discovery for them Some students commented that the solar cooked eggs tasted better than eggs boiled the conventional way.
The solar crop dryer was also well-received by the tryout students many of whom are children of farmers. One farmer parent was willing build a costlier dryer made of glass instead of plastic sheet.
For both devices, it was observed that the construction part by itself was fun for the students.
In the preparation of the energy lessons, whether enrichment or textbook material, close cooperation with the scientists or engineers concerned and the Ministry of Energy is essential for accuracy and recency of content for the dissemination and implementation of curriculum materials, coordination with the Ministry of Education and Culture is necessary.

Teaching units of energy
Another project of nationwide import is a two-year joint undertaking between the Bureau of Secondary Education, Ministry of Education and Culture and the Center for Nonconventional Energy Development of the Ministry of Energy. The project aims to disseminate

awareness in nonconventional energy through the secondary school system. In particular, the project seeks to train secondary school science teachers nonconventioanl energy resources and provide them with teaching units on these resources for integration into the school curriculum.[7]

The grade 10 science teaching units are on:

1. Energy resources of the Earth
2. Alternative Energy Sources
3. Solar Energy
4. Water and Wind Energy

The units consist of activities with questions for students. The entry points for integration and list of readings for students are also included. After completing the grade 10 units, the students are expected to be able to:

1. point out the major energy source on earth;
2. state at least ten energy conservation conservation measures at home, in school, industry and community;
3. identify alternative energy sources in the community;
4. construct appropriate devices using alternative energy sources in the community; and
5. explain science principles involved in using devices on alternative energy sources.

The concepts discussed are:

1. The major source of energy on earth is the sun.
2. Fossil fuels, the conventional energy sources, are depletable; hence the need for conservation measures and utilization of alternative energy sources.
3. Geothermal energy, solar energy, hydroelectric power, wind energy, and biomass are some in digeneous alternative energy sources.
4. A solar dryer, solar cooker, solar heater, mini-hydroelectric plant, wind powr generator and biogas plant are some appropriate energy devices.

Noteworthy in this project is the articulation of objectives and concepts of the teaching units for grades 7 to 10.

Problems and recommendations

Although some 10th grade energy curriculum materials have been developed and the government's mass-media energy conservation campaign is extensive, energy education in relation to the energy problem is not well-established in the Philippine school system. There is a need for articulation and empirical placement of energy concepts and values to be taught in grades K-12, in the different subject areas, integrating the economic, political, social and environmental issues of the energy problem. Implementation of such a spiralling energy curriculum requires the development of curriculum materials for students and teachers at each grade level.

One difficulty faced by curriculum developers is adjusting the normally slow process of curriculum development (from conceptualization to printing) to the rapidly-changing energy research and development. Often, time is needed to simplify the work of the scientist or engineer for students' understanding and to look for substitute materials to lower the cost of energy devices for class projects. With the fast-growing mass-media coverage of the energy problem, Filipino teachers will be greatly helped by materials that teach skills and give examples of organizing, synthesizing and simplifying energy data for students' use.

The mass-media energy materials often border on the information level. There is a need for curriculum developers to aim for students' greater understanding fo the concepts and principles involved in local energy devices and indigeneous energy sources. There is also a need for curriculum developers to reinforce the mass-media attempts to teach energy conservation values.

The energy problem is greatly felt in most parts of the country. Yet, the supportive energy education in the schools has only begun. Indeed the country's curriculum developers and teachers face the responsibility and challenge of making energy education in the classroom more responsive to the energy developments in the country.

Footnotes

[1] Asian Development Bank, KEY INDICATORS of Developing Member Countries of Asian Development Bank, (Economic Office, Asian Development Bank, Manila, 1981), Vol. 12, No. 1, p. 175.

[2] Ministry of Energy, TEN-YEAR ENERGY PROGRAM 1980-'89, (Ministry of Energy, Manila, January, 1980), p. 28.

[3] University of the Philippines Science Education Center, PHYSICS IN YOUR ENVIRONMENT, (Ministry of Education and Culture, Manila, in press).

[4] V. Talisayon, Diwang Pisika, 1, 19(1980).

[5] University of the Philippines Science Education Center, A Solar Cooker, (A module in experimental edition, 1981).

[6] University of the Philippines Science Education Center, A Solar Crop Dryer, (A module in experimental edition, 1981).

[7] Bureau of Secondary Education, Ministry of Education and Culture, Project Proposal on Integration of Nonconventional Energy Technologies in the Curriculum for Secondary Schools (Submitted to Ministry of Energy, 1980).

14.2

AN INSTRUMENT TO INVESTIGATE THE LEARNING OF THE ENERGY CONCEPT

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Abstract

To investigate the learning of the energy concept in school an instrument has been developed which indicates shifts in the meaning of the energy concept for students between the beginning and the end of an instruction unit or between the beginning and the end of a school

level. The instrument consists of two parts. The first part probes the meaning of the word energy *(and the meaning of the words, force. work power as well). the second part is designed to find out whether the students are able to apply the energy concept in "simple" situations. This paper serves as an introduction to the paper "Comprehension of the Energy concept: Philippine and German Experiences" presented at this conference by Reinders Duit and Vivien Talisayon. The results of learning the energy concept in two very different countries are obtained with the instrument described here.*

Basic aspects of the energy concept

The instrument presented here has been developed mainly to investigate the learning of the energy concept in grades 5 to 10 although it can be used for other purposes as well. I think there is no discussion necessary that at this school level (grades 5 to 10) the general aim of teaching energy should be to provide students with some insight to understand problems of energy supply. This aim has been the starting point of considerations on the question "Which aspects of the physical concept of energy can help the students to some insight in one of the most urgent problems of their future?"

The following basic aspects of the energy concept have resulted.

(1) *Energy as a quantity*
This aspect is often delivered when speaking of energy as precondition (or even ability) for doing work or doing a useful job in general. Energy is "something" being able to bring about changes in the world. Energy is a special (a very general kind of fuel'). Although I tried to give a somewhat conspicious notion of what is meant with the aspect of "energy as a quantity" it should not be overlooked that in physics a very abstract idea is meant[2]).

(2) *Energy transfer*
The abstract quantity being able to bring about changes or to perform a useful job (or just work) can be transferred from one system to another (from one place to another).

(3) *Energy conversion*
The abstract quantity we call energy can occur in several forms. Energy can be converted from one form to another.

(4) *Energy conservation*
When energy is transferred from one system to another or when energy is converted from one form to another the amount of energy does not change. Energy conservation is a basic principle of physics.

(5) *Value of different energy forms*
When speaking about energy one can't avoid to speak about entropy too. For the purpose of introducing energy in lower grades (e.g. grades 7 to 10) we have to restrict ourselves to a very simple notion of entropy. When energy is converted in a process the amount of energy is conserved. But although the amount of energy has not changed the "value" of energy has decreased. We can't use the energy to run the same process once more. The different energy forms are of different value. Mechanical energy and electrical energy are of high value because it is possible to convert them totally — in principle — in any other energy form. Heat energy (especially at low temperature) is of lower value because it can be converted to mechanical energy only to a certain rate.

Which of the basic aspects are needed for the above mentioned insight into problems of energy supply? I think the students should get some idea of *all* five aspects because a comprehensive understanding is not possible when restricting to some aspects only. It is obvious that the students should know something about the aspect (1) that is to know that energy is needed to run our machines or for life in general (energy in food). It is obvious, too, that some knowledge about energy transfer and energy conversion is needed. The answer the question whether the aspect of energy conservation can contribute to an insight into problems of energy supply is not as easy to answer. Of course energy conservation is a basic principle in physics and an energy concept without this aspect would not be the physics concept of energy. But this answer is not sufficient from the point of view of the above mentioned general aim of teaching energy in school. Anyway, the aspect is important in our context too. Many problems in the area of energy supply have to do with the fact that one is interested only in using energy to run a certain process. What happens with the energy when the process is finished is very seldom considered (e.g. heating up the air). It is easier to answer why the students should know something about the value of different energy forms. The first reason has to do with the fact that the notion of energy conservation may hamper an understanding of sufficient energy supply. The student may wonder why there is a problem of energy supply when energy is not lost (is conserved). The second reason has to do with the insight of researchers in the area of energy supply that the most important task in this area is not only to save energy but to minimize energy devaluation. It is not possible to discuss the 5 basic apsects of the energy concept in more detail here. One should keep them in mind during the description of the instrument in the following section of this paper because the instrument, especially the evaluation and interpretation of the data, is based on these aspects.

Description of the instrument

The instrument has the form of a questionnaire. The first part is focussed on the meaning of the words (the concept's names) energy. work, power and force. The second part of the questionnaire is restricted more or less to the application of the principle of energy conservation in simple processes of mechanics.

When the 5 basic aspects of the energy concept are concerned there is a focus on aspect (4) although the other apsects are taken into consideration, too.

Part 1

In the tasks of this part the students are asked to state the meaning the concepts have in physics if they have had physics instruction already and to state the colloquial meaning if not.

TASK 1: associations to energy, work, power and force. The students are asked to write down their associations to words presented for 30 seconds at the blackboard. Every 30 seconds a new word follows.
"When you hear or read a word, you usually associate other words which have something to do with the word you heard or read about. The following task concerns such associations. Seven physics concepts (besides the already mentioned it is current, voltage and pressure) *will be named (e.g. written at the blackboard) one after another. You have about 30 seconds for every concept in which to write down the words which come to your mind."*

TASK 2: definitions descriptions of energy, work, power and force
"It is not so easy to describe in a few words the meaning of the physical concepts energy, work, power and force. Please try anyway to find

another description for the meaning of these concepts in physics.
If you have not yet heard anything about these concepts in your physics class, give a description of the ideas you have formed about them of your own."

TASK 3: examples for energy, work, power and force
"Perhaps in task 2 you have had some problems in describing your ideas and notions about the four concepts. Maybe it is easier for you to give an example *for every concept. 'Peter stretches a rubber band' may for instance serve as an example for work. 'A new battery lights up a lamp' as an example for energy. Please write down your own examples for energy, work, power and force."*

TASK 4:

The drawing shows a "toy crane." When the switch is closed, the "crane" lifts a weight. Please describe this process by using each *of the following four concepts at least once: ENERGY, WORK, POWER and FORCE.*

If you have heard something about these concepts in your physics class take the physical meaning. If you have not yet heard anything about these concepts use the ideas you have formed about them on your own.

Comment on part 1
The meaning of the words energy, work, power and force is investigated in different aspects. The associations provide us with information about ideas coming into the minds of the students more or less spontaneously i.e. without "logical" thinking about the concepts. This method has been used by several authors.[3] Some of them (e.g. Shavelson and Preece) wanted to detect relationships between content structure and cognitive structure.

In the questionnaire discussed here I am interested in *differences between associations of different words and in differences between associations of the same word at the beginning and at the end of the learning process* (i.e. at the beginning and the end of an instruction unit). Therefore, the same scheme of categories is used for every word. Differences of the percentage in categories are the basis for interpretation.
The associations give us some information about ideas coming into the students mind when confronted with words we use in physics as names for concepts. The definitions bring us a little nearer to the logical thinking of the students in this area although one can't distinguish whether a definition is based on "understanding" or is merely learned by heart.
The examples for the concepts give information somewhat between associations and definitions.[4] The same scheme of categories as in task 1 is used for evaluating the data.
Another aspect is payed regard with the application of the words to describe a process (task 4). This task gives, therefore, some hints whether the students are able to make use of the concepts.

Of course, the results of tasks 1 to 4 don't provide us with a comprehensive insight in learning the concepts energy, work, power and force. They deal only with one area — the meaning of the words — and, of course, they do this only partly. For a more comprehensive insight tasks for application had to be included in the questionnaire. Because of time limits (set mainly by the limited patience of energy conservation is contained in the second part of the questionnaire.

Part 2
The first two tasks of this part are concerned with the motion of a ball rolling without friction and without drive of it's own in curved pathes and over slopes of different shapes.[5]

In the three graphs, a ball follows a curved path. The ball is released at the marked spot and then rolls with no drive of it's own. In all the experiments we want to pretend that there is no friction.

Mark with (1) the spot you think the ball will reach before it begins to roll back! Give a short reason for your answer!

The ball does not remain at the spot you marked with (1). It rolls back along the curved path. Mark this spot with (2). Give a short reason for your answer here too!

In this task our ball takes its course over slopes of various shapes. The speed of the ball at spot A is always so great that it can go over the slope. Again, the ball rolls without any drive of its own and we shall pretend that there is no friction.

Put a cross next to the correct answer and give a reason!
The speed of the ball at spot B is...greater than ( ); less than ( ); the same as ( )...at spot A.

In these two tasks the students are asked for a prediction of the height or the speed of the ball and for an explanation of the prediction. The purpose of these tasks is to find out whether the students are able to apply the energy concept and especially the principle of energy conservation or whether they make use of notions gained from environmental experiences.

TASK 7
The last two tasks were concerned with the motion of balls without any friction. We will now turn over to a motion with friction.

In a first trial a car is loaded only with the driver. *It starts rolling down a hill* without any drive by the motor *and comes to a rest at point A of the horizontal path. In the* second trial *the car is loaded with 5 persons. It starts rolling at the same place as in the first trial and rolls down the hill without any drive by the motor, too. Where comes the car to a rest in the second trial?*
Please mark this point with a cross (X).

Please explain your answer!
Task 7 is not as "artificial" as tasks 5 and 6. The problem is nearer to the "real" world because friction is no longer neglected. This task too shall provide us with some information about the ability of the students to apply the energy concept (especially the principle of energy conservation).
An explanation in the framework of the energy concept is of course not the only possibility of solving the problems in tasks 5 to 7. Application of the concept of force is possible too although this is much more difficult.

3. APPLICATION OF THE INSTRUMENT
As already mentioned the questionnaire has been developed to detect differences between the beginning and the end of the learning process.
It has been used to analyse the learning of the energy concept during an instruction unit in grades 7 and 8,[6] the learning of this concept during grade 6 and grade 10 in Philippines and German schools[7] and to detect learning difficulties of students at university level. To enrich the information gained from the tasks 5 to 7 interviews have been included. After the presentation of the questionnaire in interviews some students were confronted with the answers in their questionnaires and asked for some more explanation. This combination of questionnaire and interviews seems to be a very economic way to get information from a great sample and to get information in more detail from some students.

Concluding remakrs
The instrument for investigating the energy concept presented here may give some insight in learning the energy concept (and as far as part 1 is concerned, of course, also in learning the concepts work, power and force). With regard to the 5 basic aspects of the energy concept (see section 1 of this paper) tasks 1 to 4 (part 1) provide us with some information about all aspects. This is true because the schemes of categories for evaluating the data (they can't be presented here) are based on these aspects. Part 2 focusses on the aspect of energy conservation in the area of mechanics only. The instrument, therefore, gives some limited information about the learning of the energy concept. These limitations have to be taken into considerations when conclusions are drawn from the gained data.

5. Footnotes
1) see e.g.: E.M. Rogers, PHYSICS FOR THE INQUIRINGS MIND (Princeton University Press, New Jersey, 1965.)
2) see e.g.: R.P. Feynman et. al., THE FEYNMAN LECTURES ON PHYSICS (Addison-Wesley Publ., London, 1969), Vol. 1.
3) see e.g.: R.J. Shavelson, Methods for examining representations of a subject matter structure in a student's memory. Journal of Research in Science Teaching, 11, 231 (1974); P.F.W. Preece, Development trends in the continued word associations of physics students. Journal of Research in Sciene Teaching, 14, 235 (1977); G. Schaefer, Was ist Wachstum?, in: G. Schaefer, G. Trommer, K. Wenk (Ed.). Leitthemen 1. Wachsende Systeme (Westermann, Braunschweig, 1976); W. Jung, Assoziationstests und verwandte Verfahren, in: R. Duit, W. Jung, H. Pfundt (Ed.), Vorstellungen der Schuler und naturwissenschaftlicher Unterricht (Aulis, Koln, 1981).
4) The ability to give examples for a concept is of significance in learning theories like the approaches of Gagne or Klausmeier indicate (see R.M. Gagne, The conditions of learning (Holt, Rinehart & Winston, New York, 1970[2]); J.H. Klausmeier et.al., Conceptual learning and development — a cognitive view (Academic Press, New York, 1974).
5) The idea of these takes I owe: H. Dahncke, Energieerhaltung in der Vorstellung 10- bis 15-Jahriger (IPN Arbeitsberichte, Kiel, 1973).
6) Some results of these studies are reported in: R. Duit, H. Dahncke, C.v. Rhoneck, Methoden und Zwecke verschiedener Untersuchungen zur Erfassung der Vorstellungen von Schulerndie Bewegung einer Kugel in gebogenen Bahnen, in: R. Duit, W. Jung, H. Pfund (Ed.), see footnote 3.
7) Results of this study are presented by R. Duit and V. Talisayon at this conference.

14.3

COMPREHENSION OF THE ENERGY CONCEPT - PHILIPPINE AND GERMAN EXPERIENCES

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Abstract
This abstract is a sequel to R. Duit's paper on "An instrument to investigate the learning of the energy concept."[1] This instrument was administered to students in Manila (Philippines), Kiel (W-Germany) and Basel (Switzerland).[2] Preliminary results point out that physics instruction of the students enrolled in the study seems to be not very effective with regard to the learning of the energy concept during grades 6 to 10. This is true for the Philippino and the German students as well (the Swiss students get no physics instruction in this age level). The energy concept the students acquire in physics instruction during grades 6 to 10 is restricted to a limited number of the 5 basic aspects of the energy concept mentioned in R. Duit's article.[1]
The aspects of energy conservation seems to have a meaning only for about 10% of the German students, the aspect of energy degradation (value of different energy forms) is mentioned by no student at all. Furthermore there seems to be only little change of notions about energy during instruction and little change of the ability to apply the energy concept (especially the principle of energy conservation) in explaining simple processes.

Overview about the samples of the study
Energy is worked out in Manila and Kiel more or less in "traditional" manner via work. In Manila (Philippines) the students get a first introduction into this concept in grade 7. In grades 8 and 9 there is no physics instruction. In grade 10 physics instruction is given for five periods (each 45 minutes) a week. Energy is introduced as ability to do work. Only little emphassi is given to the principle of energy conservation and to the aspect of energy degradation. In Kiel (W-Germany) the students get physics instruction during grades 7 to 10 (2 periods a week, each 45 minutes). Energy is one of the guidelines of physics instruction. The concept is introduced in grade 7 and enlarged during grades 8 to 10.

Some results of the study
As the answers of the students have not been fully evaluated only preliminary results and preliminary conclusions can be presented here. Subsequent papers will deal with the findings of our study more in detail.[1]

Definitions for energy:

The students are asked in this task to write a definition for energy. Many of them mentioned "work". Sixty-two percent in the Philippines answered "Energy is the ability (or capability) to do work."

In Germany the percentage of students mentioning work is smaller and they use other definitions like "energy is stored work" or "energy is necessary for work." These definitions have been employed in their textbooks. Remarkably high is the percentage of students both in the Philippines and Germany using concepts like force, power, current and strength.

When force, power and work are concerned, in many answers there seems to be no difference in meaning between these concepts and energy. A mixing up of the concepts is visible among many students even after physics instruction about energy. When the five basic aspects of the energy concept are concerned the aspects energy transfer, energy conversion and energy conservation are only mentioned by a small number of students in Germany. The aspect of energy degradation is not mentioned at all.

Associations to energy:

Energy is linked very closely to current (electricity) and fuels for German students in grade 6. Whereas force is linked with strength. energy is linked closer with endurance and something stored (general fuel).

The associations of students in grades 6 and 10 have one remarkable difference. The percentage of physical concepts has increased. This increase is caused mainly be a larger number of energy forms and words linked with energy like energy conversion. The general features of the diagrams are more or less the same in grades 6 and 10. For instance, current and fuels are still among the associations with highest percentages in grade 10.

It is interesting to note that the associations in the Philippines are different in grade 6 and in grade 10 as well (for grade 10. It seems that energy for these students is not as closely related to electricity and fuels as for the students in Germany.
In the Philippines and in Germany a remarkably large number of students associates energy forms in grade 10. Although only some students mention the aspect of energy conversion when defining energy many of them are aware that energy can occur in several forms.

Application of the energy concept (principle of energy conservation):
The questionnaire we used to investigate students' notions about energy contains three tasks (tasks 5 to 7) dealing with the application of energy conservation. We will be concerned here only with the results for task 5 (see fig. 6). When the application of the principle of energy conservation is concerned the same general findings are obtained in all these tasks.

The students are asked in task 5 to predict the spot that the ball will reach in (a), (b), (c) and to explain their prediction.
The students in the Philippines have great difficulties with this task. A small number is able to predict the correct height on the right side when the ball is released. But almost no one is able to predict the height on the right side when the ball is going back, too. For the German students there is a remarkable difference between grades 6 and 10, especially for task 5a.

The students in Switzerland, who have no physics instruction between grades 7 and grade 10, gain only a very small increase in grade 10. It is discouraging that only a small number of students make use of the word energy and the principle of energy conservation when explaining the prediction. The number of students using these explanations is relatively high in task 5. In the other tasks of the questionnaire the number is much smaller.

Although the questionnaire was presented in a physics class and deals with associations and definitions to energy, force, work and power, too, most students do not make use of these concepts but prefer words and notions stemming from their everyday experiences. Sometimes a mixing up of physics knowledge and "everyday" knowledge is visible. One student, for instance, predicted in task 5a "the same height" and explained this in the framework of energy conservation. But in task 5b he gave an incorrect prediction and returned to explanations stemming from everyday experiences.

Conclusions
As mentioned above already only preliminary conclusions can be presented here because the answers of the students have not been fully evaluated yet.[1]

With regard to the five basic aspects of the energy concept, the knowledge obtained by our students during physics instruction is rather limited.
This knowledge seems to be not sufficient to enable them to have an insight into the problems of energy supply. The students have, for instance, great difficulties to make use of the principle of energy conservation even in simple processes. The conception of energy degradation (value of different energy forms) is not established in the students.

We think that our findings point out that energy should not be restricted to the ability to do work.
Introducting energy in the "traditional" way seems to cause severe difficulties because energy is linked with electricity and fuels more closely than with processes in mechanics. It would be interesting to investigate whether the approaches on dealing with energy in school presented at this conference[4] are able to overcome some of the learning difficulties described here.

Footnotes
[1] R. Duit: An instrument to investigate the learning of the energy concept. This paper is contained in these proceedings, too.

[2] This study has been carried out during a stay of R. Duit at the Science Education Center of the University of the Philippines (UP-SEC) in the beginning of 1981 as part of a cooperation between the IPN in Kiel and the UP-SEC in Manila. Very many thanks to Prof. Dr. Dolores Hernandez, the director of UP-SEC, and the German Academic Exchange Service (DAAD) for facilitating this stay.
Very many thanks, too, to Genelita C. Balangue who kindly processed the answers of the Philippine samples, to Hans Dorr who evaluated patiently the answers of all samples according to complicated schemes of categories and to Hans Brunner who organized the study in Switzerland.

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[1] see the papers of G. Delacote. U. Harbor-Schaim, F. Herrmann. and G.B. Schmid presented in these proceedings.

14.4

ENERGY IN SCIENCE CURRICULUM OF PRIMARY SCHOOLS: IN SERVICE TRAINING FOR SCIENCE TEACHERS IN A DEVELOPED COUNTRY

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Introduction

Since 1979. at the Sede Los Angeles. Universidad de Concepcion. Chile. a research project has been developed. whose main objective is training teachers in service, working together as a research team, designing a science curriculum adequated to the local teacher-student-school conditions.

This way we want to make teachers realize their own capacities for teaching science, although most schools do not have science equipment and teachers must be always seeking for equipment substitutes. We want teachers to understand that science should be taught according to the children environment, taking advantage of all what is familiar to them. Children who live in farms, which is the case of many of those in our region, do know a lot about science due to their daily experiences and teachers should develop the science curriculum considering this informal knowledge.

In other words, one of the main purposes of the project is to make teachers realize that the national science curriculum might be re-orgnized according to the local conditions, around any of some topics of interest for the children, and that the selected topic could be the "core" for the whole science course.
Since few topics in science are wholly significant unless considered in relation to energy, we propose ENERGY as one of these "CORE." Besides, being the ten schools which participate in the research project located in a region where the hidroelectric centrals are specially important and a job source for most of the people of the region, we want to emphasize hidroelectric energy as a special topic.

Science curriculum in Chile, for primary schools, is organized around five main objectives which are developed along the eight years of primary school:

1. Scientific processes
2. Living things and the environment
3. Man as a biological being
4. Matter and energy
5. Earth and its place in space

Project research

The research project development began in 1979. We selected ten schools which presented characteristics that could be considered representative for our region. Thus we have six small rural schools and four urban schools (two small and two big ones). The project considers the work with children from 10 up to 14 years old — 5th to 8th year of primary school. Some of the sample school teachers have specialization in science, but most do not. Nevertheless, this is a common characteristic of our schools and this is not considered a disadvantage for the research project development.

In 1979 the research objective was to make a diagnosis of science teaching in our region. The information obtained was used for defining the sample of schools for the project development.

In 1980 we started working with teachers on weekly sessions where they designed the science curriculum for the 5th grade according to the school-students- and own conditions and then tried the material with the students, evaluated the students achievement and fed back the system. During this year, 1981, they are designing material for the 6th grade. The project will be finished in 1983, when the students complete their 8th grade.

Energy and the science curriculum

We selected two main topics as core for the development of the 6th grade science curriculum: Health and Energy.
Eight of the ten schools are working around "Health" as Core Curriculum and two schools decided to have "Energy" as a core. Both teachers at these last two ones do not have specialization in science.

Table I presents some of the class characteristics on both schools.

TABLE I. - Students characteristics in schools using ENERGY as CORE.

The objectives which should be reached at the end of the course are:

1. Scientific Processes.

General Objective: Ability for defining, interpreting data and formulating conclusion.

Specific objectives:

a. To formulate definitions which properly describe an object, a living thing or a phenomena, with respect to the content in which it is used.
b. To describe and to experiment using properly the words "independent variable," "dependent variable" and "constant variable."
c. To infer from comparison of informations taken from two or more tables or related graphs.
d. To be able to tell observation from inference, prediction or formulation of an hypothesis.
e. To formulate hypothesis in order to explain a fact or a phenomena, considering a set of observations and/or inferences.

2. Living things and the environment.
General objective: To understand and to realize interdependence relations among living things and their environment as factors which favor subsistence.
Specific objectives:
a. To recognize that populations living on a certain place constitute a biological organization level called community.
b. To distinguish some of the characteristics of a biological community: competence, fluctuation and limiting environmental factors.
c. To recognize the existence of a food interdependence among living things (food chain).
d. To describe some types of relations among species of organisms in a community (symbiosis, parasitism, etc.).
e. To describe one community of the region and to recognize that it also includes microorganisms.

3. Man as a biological being.
General objective: To understand and to value the importance of perserving and improving health.

Specific objectives:
a. To recognize the illnesses affecting man are due to different causes, and to emphasize those due to microorganism.
b. To describe some characteristics of common infectious illnesses, indicating proper prevention and treatment.
c. To appreciate the influence of factors which limit the defensive capacity of organisms (bad nutrition, alcoholism, drugs).
d. To describe and apply procedures of basic first aid techniques for prevention of common accidents.
e. To recognize the need for applying basic norms of environmental sanitation, litter disposal, drinking water supply, green areas provision, etc.
f. To value and to appreciate the contribution of science men in relation to the fight against illness.

4. Matter and Energy.
General objective: To identify some matter properties, certain types of energy and its transformations.

5. Earth and its place in space.
General objective: To know the main characteristics of the solar system.
Specific objectives:
a. To describe the solar system considering that planets turn around the sun along characteristic orbits.
b. To describe the sun and moon clipses as a function of relative positions in the sun-earth-moon system.
c. To value and appreciate the science men research work with respect to the solar system.

Evaluation
Due to time limitations, in this paper we will only develop the first three Units which correspond to the first semester of the year (March-July); the last three ones will be developed during August-December term.
Below we give a description of the activities designed by the school teachers for each Unit or Section, which they think will help the students to reach the corresponding objectives.

Section 1: Energy, a vital principle for man.

General objective: To understand that human organism requires a constant supply of food and oxygen and a permanent disposal of residues.
To understand and to value the importance of health preservation and improvement.
Specific objectives:
a. To identify main food sources: to classify food with respect to its components and function.
b. To describe the characteristics of a balanced diet and to establish its contribution to health.
c. To recognize the need for applying basic norms of environmental sanitation, specially that of green areas provision

Activities
·Presentation of drawings
·Explanation and comments on drawings
·Identification of food with respect to origin
·Classification of food according to its composition
·Making distinction between plastic, energetic and functional food
·Design of 2 x 2 tables for food classification
·Inquiries about the characteristic of a balanced diet
·Comments on food requirements for man with respect to the kind of work fulfilled.
·Inquiries about the way substances are transformed through metabolism into vital energy
·Establishing a relation forces and energy
·Distinguishing mechanic from intellectual work
·Comments on diets required for each one of the different jobs done by man
·To make inferences related to consequences of a non-balance between excessive waste of energy and its reposition
·To design weekly diets for people fulfilling mechanical or intellectual work
·To prepare a wall magazine presenting model diets for school lunch
·To investigate on combustion and its collateral effects
·To comment on the importance of green areas provision for industrial centers and big cities
·To talk about existing dispositions and to propose new ones for adoption, in order to reduce contamination.

Section 2: Natural forces as used by man
General objective: To acknowledge the natural forces and its utilization by man
To be acquainted with gravity as a distance acting force which determines the objectives weight.
Specific objectives:
a. To recognize gravity as a force which determines the bodies weight.
b. To study experimentally mass, volume, and density.
c. To acknowledge natural forces which man utilizes for energy production.

Activities:

·Measurement of forces
·Inquiries about gravity and to relate it with Newton's work
·Relation between gravity and weight
·Definition of mass - volume - density
·To establish relations between mass, volume, and density
·To comment about uncontrolled effects of natural forces
·Inquiries about man utilization of natural forces for his benefit
·To design models of water mills and wind mills

Section 3: Energy and its different manifestations
General objective: Students should be able to recognize energy manifestations such as heat, light, electricity, magnetism and name energy transformations.
Specific objectives:
a. To experiment with energy in its different forms.
b. To transform energy from one kind to another.
c. To recognize the energy manifestations in daily life.

Activities:

·Inquiries about potential energy
·Inquiries about kinetic energy
·Inquiries about chemical energy
·Transforming experimentally chemical energy into electric energy
·Building a steam machine
·Drawing some heat engines (internal and external combustion), identifying the energy sources in each case
·Location on regional charts of the principal coal layers and oil refining plants
·Inquiries about production and consumption of coal
·Inquiries about sub-products of oil; making a collection of samples
·Visiting an hidroelectric central
·Comments on uses of electric energy and other types of energy
·Design of electric circuits
·Inquiries about future energy sources and comments about world energy becoming scarce.

For each one of these sections the teachers prepare some student guides for practical work. These guides are worked through by two or three students. Each group works on a different guide and after finishing the work the students exchange results obtained and comment on them, arriving to some conclusions. This way the teacher will be able to reach the different objectives stated for the section and the students will be taken through practical work to the understanding of all important concepts considered in the course.

The evaluation instruments for each section are prepared by the school teachers and then revised by the research team evaluator. The evaluation is criterion referenced and objectives are the criterion used for item construction.

Evaluation results indicate that students achievement is fair and that the objectives are reached. The percentage of correct answers for the first section was 63%.

Conclusions

Traditionally science teaching in Chile at primary schools has come across many obstacles, specially due to teachers attitudes, who associated science teaching with sophisticated equipment. Being schools generally unequiped, teachers avoid the teaching of science or just make students copy a certain amount of contents related to science which the children memorize not understanding what really is behind these facts.
Teachers working with the research team, and being considered as part of it, have come to realize the importance of practical work related to the children surroundings and have received in service training by means of their participation on the research project.

We, as managers of the project and as university teachers, just guide the school-teachers and help them with suggestions, bibliography and assistance. We don't tell them what to do or how to do it; we just present them with different approaches for the curriculum development and they plan, design and apply with the students their own approach. They have come to consider their teaching as an hypothesis: "Effective teaching by means of a different approach to science curriculum."

This kind of service training seems quite effective for developing countries, where possibilities for post-graduate courses are few and most teachers do not have the opportunity to assist to a science education college. The kind of work done with the teachers, being themselves part of the research team, has changed their attitude towards the teaching of science, and this is for us the best sign of success.
Together with the above, flexibility as a characteristic of the Chilean scienc curriculum allows the teacher to select any important topic related either to the students interests or to local, national or international requirments, such as ENERGY.

14.5

SOLAR ENERGY PROGRAMS — FROM KINDERGARTEN TO UNIVERSITY —

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Abstract

A series of educational programs has been developed to familiarize various population segments with the potential of solar energy. Initial programs were aimed at developing elementary school curricula, but the same approach can apply for all grade levels. In addition, materials and demonstration devices developed have practical application for the solar designer and are presently used as instruction tools at the university level.

Salient features and accomplishements of this program include:.

a) Solar Energy Curriculum for Elementary Schools.
b) Secondary School Programs.
c) Development of Solar Device Demonstration Kits.
d) Development of Broad-Based Educational Programs.

I. Introduction

The University of Southern California, working with the Caltech Jet Propulsion Laboratory, is developing a series of educational progams to familiarize various population segments with the potential of solar energy. The initial stages of the program were aimed at developing elementary school curricula, but it was felt the approach could be applied for all grade levels. In addition, the materials and demonstration devices developed have practical application for the solar designer, and are presently being used as instructional tools at the university level.

The more salient features and accomplishments of this program include:

Solar Energy Curriculum for Elementary Schools - This program was developed under contract to the U.S. Department of Energy, and has been tested throughout the U.S. To date, over 1000 copies of the curriculum have been distributed to 40 states and to selected groups outside the U.S. General acceptance has been favorable. Development of the materials and field tests results are described in Section II of this paper.

Secondary School Programs - These were developed for schools in Southern California, and established a network of weather stations throughout the Los Angeles basin to monitor solar insolation and augment existing weather data. The methods used, findings and suggestions for implementing similar networks in other regions are discussed in Section III.

Development of Solar Device Demonstration Kits - These kits were developed to be both practical and instructional in nature for use in primary and secondary schools. For example, the "Sun See" and "Five Cent Solar Tracker" are readily assembled and can be used effectively in the design of solar collectors. "Sun See" can measure certain useful parameters in collector design, while the Tracker can be used in site selection and other related activities. These are discussed in Section IV.

Development of Broad-Based Educational Programs - All of the elements above can be used to develop broader educational programs about solar energy, aimed primarily at the general public. This is discussed in Section V.

II. Solar energy curriculum, K-6

Funded by a grant from the U.S. Department of Energy in October 1977, a team led by Dr. Seymour Lampert of the School of Engineering at the University of Southern California generated lessons appropriate for a 6-week unit in solar energy for students at various elementary school levels. Dr. Gilbert Yanow of the Jet Propulsion Laboratory, Dr. Kathleen M. Wulf of the School of Education at the University of Southern California, and 21 teacher specialists recommended by school districts in Southern California, pooled their expertise on the project.

Systems Approach

Since time and funding were limited, the USC/JPL team decided a systems approach was the most effective way to create the new curriculum. The plan was to obtain simultaneous contributions from each member, concentrating on their respective areas of expertise. Thus, Drs. Lampert and Yanow contributed information on content and subject matter, Dr. Wulf was responsible for educational psychology aspects, and the teachers suggesed practical applications for the classroom. The advantage of this approach was the team, collectively, was more effective and creative than as a group of individuals.

All participants attended six 8-hour workshos during the winter of 1977-78. In the first meeting, the content contributors shared basic information on what solar energy is, how it can be used, and why it is a reasonable energy alternative. However, the teachers were concerned about needing a stronger background in science (although they were considered the best by their school districts) before they would feel comfortable designing new lessons for students.

At that point, the subject matter contributors became resource individuals to answer any questions at any time during the workshop. Once the parameters of the content were identified, the educational psychologist and an assistant worked with the teachers to establish goals, performance objectives, and to analyze the tasks for appropriate sequencing. By agreement, it was decided to work in groups to write the goals and objectives, upper grade and primary grade teachers clustering separately.

From the beginning, it became clear to everyone that sequencing of the objectives was more important than trying to assign grade level labels to particular activities. Therefore, the teachers began thinking in terms of tasks, i.e., what does the studnets have to know to be able to achieve a given objective? In this way, required "prerequisite" behaviors were built into the curriculum at earlier stages. Similarly, concept development becomes more important in succeeding stages, exposing a young student to a new idea in the first level of lessons (e.g., the size of the solar system), and then building on that introductory knowledge with more difficult activities at later stages.

"Non-Reading Formats for Lessons"
A number of teachers stipulated the lesson plans developed from the stated objectives should not be based totally on reading ability. Their wide experience in the large urban Los Angeles area made them aware of enormous ranges in student achievement. as well as problems with reading, since a large percentage of the students speak English as a second language. For these reasons, the curriculum package included worksheets where a child can mark temperatures on a picture of a thermometer and can color code findings of a solar experiment.

Young students, and those with limited reading ability can demonstrate their mastery of objectives in a number of ways. In the case of Kingergarten pupils, teachers are encouraged to use a checklist entitled "Suggested Participation Observation Sheet" to record student involvement in tasks.

Another strategy is to use a project-designed laboratory worksheet requiring the student to draw a "prediction" in answer to a teacher's question, e.g., "What do you think will happen if a plant doesn't get sunlight?" When the experiment is completed, the student records the observation pictorially. Another example of mastering a concept with limited reading skill is a worksheet "Looking at Energy," where the student considers five forms of energy in terms of three desirable criteria.

Preliminary Evaluation
Since field tests were planned in elementary schools around the U.S., the major concern was to obtain meaningful data about: 1) student achievement; 2) student opinions on lesson effectiveness; 3) parent opinions on lesson effectiveness and; 4) teacher suggestions for improvement. All of this was to be accomplished with minimal paper-and-pencil testing and writing requirements for teachers.

To assess lesson effectiveness from the student's point of view, an evaluation system was prepared to assess student reactions. To the basic statement, "I want to learn more about solar energy," responses of "not much," "some," or "a great deal," were offered as options. Younger primary students cold respond using a scale of "happy" to "sad" pictorial representations.
One thrust of the solar energy lesson was to raise awareness about energy conservation issues in children. The team set out to measure a student's out-of-the-classroom behavior by asking parents if: 1) their child told about studying solar energy during the past few weeks and; 2) whether their child advised about conserving energy in the home.

Finally, teachers participating in the field test were asked to contribute their student achievement data, student opinion data, parent opinion data, and their own appraisal of the lessons. Dealing with each lesson taught, teachers were asked to respond to one question: "In your professional opinion, how can this lesson be improved?"

When the data is complete in 1981, the results of the first large-scale evaluation will be reported. Appropriate recommended changes will be incorporated in the curricular materials and, with the formative evaluation completed, the curriculum will be made available by the Department of Energy for nation-wide use.

III. Secondary School Programs
In 1977, a cooperative program was initiated between the Jet Propulsion Laboratory (JPL) and the Southern California Edison Company (SCE) to develop an educational supplement about solar energy that could be provided to science teachers in the Southern California area. The aim of the program was to provide the high school teachers with materials they could use in an educational atmosphere, and materials students could use with significant scientific value.

To accomplish this, JPL developed a series of specialized scientific kits. The initial kit, and perhaps the most useful, was a silicon cell pyranometer kit[1].

Detailed assembly instructions are included with the hardware components. The assembly manual contains 47 detailed check-off steps, and 20 explanatory photographs. These instructions were field tested with the cooperation of several high schools in the JPL area. For the teacher and student, a general information and operation manual was also included. This manual discusses the general properties of a pyranometer, and the accuracy of the particular unit supplied. All kits were pre-calibrated before being sent to the schools and, after construction by the students, a member of the JPL team visited the high school to recheck the calibration. Additional information supplied included detailed operating instructions on how to use the pyranometer kit, operating a chart recorder (presented to the students by SCE), and a variety of application modes.

Once the units were installed and checked out, periodic data gathering was done by all the high schools in the program. This data was then returned to JPL, where microcomputers were used to reduce the information. Students and instructors were also given access to these computer programs at their own high schools. In this way, the students realized they were not simply going through an educational exercise, but were collecting information for a recognized scientific institution.

The silicon cell pyranometer kits were produced at a cost of $50/kit. The major problem with a silicon cell pyranometer is color sensitivity. It is more sensitive to reds than the human eye and, as a consequence, gives false readings of higher light levels during early morning and late afternoon hours. This is shown in the +7.1% error based on a whole day integration. However, as recommended to the students, a -3.0% correction factor was normally applied to whole day integrated values.

In addition to the solar insolation data gathered with the pyranometer kits, many student and teacher teams stated recording temperature, humidity and wind data. Thus, the pyranometer kit, in many cases, could be considered an ice-breaker. Once a solar energy curriculum was initiated as part of the science program at high schools, numerous other applications were quickly brought in. Many schools that started in the program initially now have extensive solar energy programs of their own where the pyranometer kit is only one part of that activity. Other kits included in the demonstration materials given to the teachers and students were a thermo-syphon hot water heating system, and a battery charging unit using photovoltaic cells.

IV. Solar device demonstration kits
Several solar device demonstration kits developed for the elementary school curriculum can also have broader applications and usefulness at the high school and even university levels. Two such devices are discussed in the following paragraphs.

The "Sun See"
Originally designed to acquaint elementary school students with meter reading, the "Sun See" shows greater versatility as a scientific instrument. The unit consists of a silicon solar cell wired to a milliammeter. When exposed to the sun or an incandescent light source, it

will record an output proportional to the light intensity. When properly calibrated, it can act as a pyranometer to provide realistic quantitative values of solar insolation. Even without calibration, this instrument can be used to determine a number of useful parameters associated with solar collector design, and can serve as an exploratory device for site selection. Four approaches for determining these parameters are discussed below.

Measuring Transmissibility

The "Sun See" is placed on a horizontal surface with the solar cell facing the sun. The unit is rotated until a maximum reading is obtained on the milliammeter. This reading becomes the reference value, proportional to the total solar insolation (I_o). The glazing material (glass, plastic, etc.) is placed in front of the solar cell and the reading obtained on the meter is proportional to the radiative flux (I_R) received by the cell. The ratio I_R/I_o is roughly proportional to X the transmissibility. This parameter is used in rating glazing materials for solar collectors.

Reflectivity/Absorbtivity

Reflectivity can be determined using methods similar to those used for transmissibility. The solar cell, however, is turned 180 degree from the direction of the sun after the reference I_o reading is obtained. The reflecting or absorbing surface is then placed in front of the cell, and a reading of the reflected portion of the sunlight (I_r) is taken. The ratio I_r/I_o is proportional to X the reflectivity. If a value for absorbtivity is desired, it can be calculated by. Keep in mind these are comparative values and not exact, but they can be used to evaluate a number of candidate surfaces. High absorbtivity and low reflectivity in certain wavelength ranges is desirable for surfaces used in solar collectors.

Concentrators

The effectiveness of various reflecting surfaces selected by the process above can also be measured while varying mirror configurations relative to the solar cell, and observing the readings on the meter. The optimum angles and configuration can be readily determined with the instrument. An extension of this technique can also be applied to more sophisticated concentrators, such as the Compound Parabolic Concentrator (CPC).

Occultation Experiments

A simple occultation experiment can be performed, giving a qualitative answer for the amount of diffuse radiation to the total radiation at any given time of day. First, the reading proportional to I_o is obtained, and then the cell is shielded from direct sunlight with opaque material. The value derived is proportional to the diffuse radiation, I_d. The ratio I_d/I_o gives the fraction of diffuse radiation to total radiation. this is an important parameter for obtaining the ratio of beam radiation (I_b) to total radiation.

Lambert's Law Experiments

Another experiment that can be performed with the "Sun See" instrument is proving light intensity varies inversely as the square of the distance. The experiment can be performed with an incandescent light. The instrument is placed at a distance that produces a "one unit" reading on the ammeter and the actual distance measured. Then, the instrument is moved toward the light source until a "two unit" reading is obtained and the distance noted. Intermediate readings and distances are recorded and compared with a plot of I 1 d

These applications of the "Sun See" instrument are only a few of the numerous comparative analyses that can be devised with a little ingenuity on the part of the user. This type of investigation, however, should not be confused with very carefully performed experimental measurements.

The Five-Cent Solar Tracker

Another application of the "Sun See" unit could be solar tracking. While observing the ammeter, the solar cell can be rotated until it reads maximum, giving the azimuth direction measured from the solar south (not magnetic south). Tilting the cell until its surface is normal to the sun then gives the altitude angle. However, a simple device, called "The Five-Cent Solar Tracker" can be constructed to do the same thing. Basically, the tracker is an inexpensive verson of a number of solar site selection instruments. An old shoe box can be used, or any similarly shaped carton. Azimuth, altitude, and profile angles may be readily obtained by measuring the shadows cast inside the box. The baseline of the box must be on a horizontal surface and must be oriented as shown in a true north-south direction (not magnetic) Tracking involves measuring the sun elevation and azimuth angles as the day progesses. The azimuth angle is noted as positive before solar noon, and negative after solar noon. At equinox, sunrise will be at +90°, and -90° at sunset.

V. GENERAL PUBLIC INFORMATION PROGRAMS

During the course of these activities, two adult education programs were also held. A 9-week "Solar Energy for the Consumer" course was given at Pasadena City College, and a weekend course for the construction industry was given at the University of Southern California. Both courses were well attended. "Solar Energy for the Consumer," had approximately 100 students, and the course for the construction industry had approximately 50 attendees. Both courses used the same general format i.e., a systems approach to the education of the particular students. Specific teaching goals were established, and then appropriate materials supplied, with heavy emphasis placed on hands-on activity.

Many of the activities described in the Elementary School Curriculum have been used by high schools and universities. The "10-Cent Hot Dog Cooker" activity, described in other papers, has been used in many high schools, and the Riverside City College uses it as a starting project for initiating their air conditioning, refrigeration/solar students. Here, the students are told it is an elementary school project and they should use their own imaginations and skills to improve upon the basic design.
Some schools have also used the solar hot dog cooker as a pseudo-science project. After the students construct these devices, contests are held to see whose device will cook a hot dog fastest.

As a final point, and perhaps the most satisfying, the authors have been told by many teachers thrust into the position of teaching science without the appropriate academic background, that these materials enabled them to carry out a successful science program at their respective elementary schools. Using the approaches described in this paper, solar energy concepts are easily understood by both teachers and students. Because of the heavy emphasis placed on hands-on activities, these lessons have provided an exciting and somewhat novel approach to the traditional teaching of science.

Footnotes

1 A pryranometer is a scientific instrument used to precisely measure the total amount of sunlight falling on a given area.

2. Lampert, S., Wulf, K.M. and Yanow, G., *A Solar Energy Curriculum for Elementary Schools*, Office of Solar Applications, U S Department of Energy, Feb. 1980.

3 Lampert, S., Wulf, K.M. and Yanow, G., "The Dissemination of Solar Energy Curriculum," Proceedings of 1981 Annual Meeting, Philadelphia, PA, ISES, Vol 4.2.

SESSION 15: ENERGY EDUCATION IN DEVELOPING COUNTRIES

15.1

ENERGY EDUCATION FOR AFRICA: possible Policies for the future

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Abstract
Africa's energy requirements will be satisfied after, and only to the extent that, a number of obstacles will have been overcome. These obstacles include the following: a lack of the will to act; the absence of policies to guide action; the inadequacy of data that might facilitate the preparation of needed policies; shortfalls of (and even shortcomings in) those who formulate or implement policies; widespread suboptimal utilization of energy resulting, essentially, from ignorance; and, as might be expected, Africa's poverty. The aim of this article is to identify among these obstacles those that are amenable to removal by the thrust of educational effort and to sketch the sort of policies their removal would require. Five broad policies are suggested. One seeks both qualitative and quantitative improvements in human energy and in its utilization. This policy is a consequence of the dominance of labour in African economies. A second policy has as its aim a greater and more balanced provision of specialized skills - especially of skills that are catalytic to the removal of the obstacles mentioned. This policy and the first imply educational reform, the subject of a third policy. A fourth policy, concerning research, is basically a call for relevance - again. Co-operation is crucial to the economic survival of Africa, and is the subject of the last policy. But if the past is any indication, this subject will continue to attract less attention before it attracts more.

Reasons
Limits obviously exist as to what education alone can achieve in satisfying Africa's energy requirements, and there may be no better illustration of this than the energy crisis itself. For, since the onset of the crisis in 1973, developing countries generally, but most of those in Africa particularly, have increasingly become victims of one dual tyranny upon which education appears to have litte immediate influence. This is the onslaught, on one hand, of the oil crisis itself and, on the other, of the retaliatory measures that crisis provokes in the developed countries. Owing to the double grip of these twin circumstances, nearly all African countries (naturally, excepting the oil-producers: Algeria, Gabon, Libya and Nigeria) now spend larger and large fractions of their convertible incomes on oil (10 per cent in 1973 but now nearly 50 per cent in the case of Tanziania, for example), and also on their imports from the developed world. At the same time, while this tyranny rages, African countries are nowhere near finding effective ways of parrying either of its blows and recouping their losses. On the contrary, for a long time to come, they seem destined to continue taking both blows lying down. If the fortunes of African countires resemble thus those of a feeble and helpless merchant locked in commercial combat with powerful and greedy adversaries, limits to what eduction alone can accomplish in Africa begin to emerge.

Nevertheless three important reasons remain which indicate that African countries can still turn to education profitably. All of them are familiar, but they can bear repetition. One is related to the first function of education - that is , to the transmission of knowledge. This function has as its aim the improvement of the manner in which individuals interact with each other and with their environment. It is therefore of great interest of Africa, where few changes are as crucial as those that produce such improvement.

At present, in Africa, the interaction of individuals with each other and with their surroundings is generally ineffectual. It is purposeful, of course. But often it is not very productive. The reason is that it consists of efforts that are neither sufficiently methodical nor adequately discriminating in their use of muscle power. There are not enough systematic attempts to exploit connections between events or relations between objects - indeed efforts are not rarely pitted against both. Too often dealings with the environment are prompted by beliefs that are not results of a systematic interrogation of nature. Too often those dealings are influenced by the unstated expectation that, in choosing its response to human effort, the environment is guided by the normal rules of proper human conduct. One gets the distinct impression that special pleas may be addressd to the environment, which etiquette then obliges it to consider. Not seldom such pleas take the place of the effective acts that manipulate nature through its own laws. The individual's interaction with his environment consequently is inefficient, with the result that the range of possibilities that the environment offers him is severely limited. Not surprisingly, the majority of the African populations (69 per cent in 1973) live in conditions of "extreme poverty" (Kingue 1979, p 95). For them, it is no mean achievement merely to hold the line and keep body and soul together. Even for the rest, work is noted more for its drudgery than for its rewards, and life more for its struggles than for its pleasures. This cries for redress.

The instrument appropriate for bringing about the required improvements is mass education. For it to be immediately effective in this, that education has to be aimed in the most direct manner possible both at an efficient utilization of the individual's own energy and at a rational exploitation of the energy resources in his environment. Provided proper arrangements are made, education can achieve both of these aims. Thus the first reason.

The second reason relates to the second function of education - namely, research. In order to meet their energy requirements, it is clear not only that African countries will have to devise and employ more efficient ways of utilizing their existing energy supplies, but also that they will have to seek new energy sources. To each of these ends, the present stock of knowledge no doubt will prove useful. It is equally certain, however, that in addition to existing knowledge new knowledge will be required as well. Thus the need for research. Thus also the second reason.

The third reason is a subsidiary one and might have been subsumed within the preceding two, but is separated from them here in order to accord to it the special prominence it deserves in Africa. This is the necessity of collective action. Education can, and should, pave the way for collective action by fostering in students attitudes that predispose them favourably towards activities aimed at the benefit of their communities. This is not a question of ideology but of survival. Many African countries are simply too small or too weak to be economically viable (Adedeji 1979, p 87); at the same time, each of them guards its separate sovereignty jealously. In unfortunate circumstance such as these, survival requires at least the co-operation of African countries in the expoitation of their energy resources particularly and in the pursuit of their common goals generally. "Collective self-reliance" is a notion now very much in vogue in Africa (although, regrettably, more in word than in deed). It is a concept not entirely without merit, especially since many African states will almost certainly never attain individual self-reliance. To see the significance of the idea, one need only compare the wealth of individual African nations with the vast resources of the United States or the Soviet Union, or, even, with the great potential of "the patiently organized labour of 900 million Chinese". Such comparison makes it evident that, if African countries insist on each blazing its own trail, they should expect not only an ever-widening gap between themselves and the richer nations, but also their reduction into mere appendages of those countries (Tevoedjre 1979, p 17).

At present, intra-African co-operation is impeded by especially one misfortune - namely, the evanescence of African political alliances. These alliances, as is well-known, are usually born of the *personal* rapport existing among heads of state. Therein lies their weakness: They are co-terminous either with that rapport or with the principals' tenure in office. Co-operation flourishes or withers depending not so much on the presence or absence of mutual interest as on the concord or discord among those who fortune has placed at the top of their respective heaps. In short, "African governments have not yet learnt how to insulate (their arrangements for economic co-operation) from the vicissitudes of political differences" (Adedeji 1979, p 61). Thus at the continental level, even at the national level, within the same borders, the individual not only needs to learn, and education to teach him, to subordinate narrow self-interest to the broader requirements of his community, but also must acquire, and education ought to reinforce in him, the habit of foregoing present satisfaction for the sake of future advantage. This is especially true with respect to the exploitation of energy resources. Hence the third reason.

Obstacles

For such reasons as these, then, African countries may look to education for contributions towards the satisfaction of their energy need. A most natural noise to make now would be to exhort African educators to get on with their job and start delivering the goods. But instead one should ask why that is not happening already. For this quickly reveals a host of obstacles that will have to be removed first if the contributions of education are to be forthcoming, and, in so doing, indicates the sort of policies that are required to guide action in the energy sector if Africa's energy needs are to be met. The obstacles are well-known; they grace the reports of several conferences of African ministers. Here there is a need only to broach them briefly.

One of them is what has come to be referred to popularly as "the lack of political will" (ECA 1979, p 39; OAU 1980, p 117). A typical scenario here is that of governments praising to the skies a project (perhaps a proposed power dam on a shared river) and actually including it in their development plans, but prevaricating when the moment to act finally arrives.

Not rarely, government go the whole length of, and incur considerable expense in , preparing elaborate plans which, right from the start, they have no wish to implement. This willed impotence is in no small way related to the fact that in Africa those who wield power tend to see in the apparatus of government a device for their own personal advancement, not for the welfare of the citizenry. Even in the most propitious circumstances, when governments have the will to act, they seldom have the *ability* to do so, since either the technical competence or the material resources action requires will still be missing. This is why, when they formulate a policy, that does not mean government support for that policy exists right there. While this obstacle may not be confined to African alone (Everywhere, only the unsophisticated expect governments to remember each of their numerous promises, let alone to fulfil them), because of the strong coupling between government action and people's lives that exists in Africa, nowhere are the effects of government in action as devastating as they are on the African continent.

But if African governments do not always have the wish to implement their own policies, this is at least partly due to another obstacle. A second obstacle (with regard to energy, at any rate) is that "most African countries" (OAU 1980, p 115) do not have those policies to begin with. To be sure, proposals of needed policies exist. They may be gleaned, for example, beneath the rich embroidery of the resolutions of summits of African heads of state. Often, however, these proposals contain only implicit policies; not rarely, they are really convoluted restatements of the problems they are expected to solve. Explicit policies are rare, and when one examines African practice with regard to energy, say, one is struck instead by a preponderance of ad hoc edicts that rely heavily on the force of administrative measures - rationing, levies, exhortations, admonitions, prohibition, bans, fines, and so on. Obviously such controls cannot be dispensed with altogether - especially as tactics in short-term strategies. But, in Africa, there is little indication that they ever serve much useful purpose: the efficiency of the policing instruments that they presuppose is simply not there. Consequently, more often than not they only multiply opportunities for curruption.

This lack of policies is in part a product of the absence of the will to act mentioned earlier; where there is no intention to act, there is no action to plan. But it is also a product of a third obstacle. This is the paucity of existing data that might be used to formulate those policies. African countries have among them vast natural resources which make them "one of the richest regions of the world". In particular, they are rich in energy resources, being generously endowed with solar and geothermal energy, coal (1.3 per cent of the world's total potential), hydropower (20 to 40 per cent of the world's total potential), petroleum (20 per cent of the world's "trade oil" when the United States and the Soviet Union are excluded), and nuclear energy (20 to 30 per cent of the world's thorium and uranium) (ECA 1979, p 9; UNDP 1980, p 2; OAU 1980 , p 4). Only spotty inventories of these resources exist, however; many of the resources are known only in the roughest terms. While such information is apparently "hard" enough as a basis for brilliant speeches and knowledgeable statements by government ministers, it is demonstrably too "soft" as a foundation of development policies and programmes of action. Where reliable data exists, its analysis can greatly facilitate the formulation of policies, but the same exercise is pointless when most of the data would have to be invented.

Resource inventories, do not exist largely as a result of a fourth obstacle - namely, shortages of, and inadequacies in, staff responsible for their preparation. Obviously this is generalizable, since the scarcity of competent personnel is not confined to the energy sector alone. In general, ministries are not always staffed with people capable of analyzing the policies which they administer, and of preparing (or having prepared) good feasibility studies of proposed projects. "Experience must be acquired in planning a project, getting it started, keeping it on schedule, amending it to take account of unforeseen snags, and evaluating its results from time to time" (Lewis 1966, p 21). The absence of such experience is one of Africa's greatest stumbling blocks. Yet even if this were to be overcome, little progress will have been made unless at the same time decision-makers conquer the urge "to act politically" and learn to pay heed to the advice of their technical experts. In this connection, it needs to be said that many African cabinets have yet to learn not to make an important decision until civil servants and technical advisers have examined the matter from every angle.

A fifth obstacle is the circumstance that any significant change in Africa means that millions of rural peasants must be induced to shed some of their old ways and adopt new ones. At the same time, since the vast majority of them (about 70 per cent) are illiterate, the multiplier effect literacy normally has on the acquisition of new skills is almost absent, so that the absorption of new ways is extremely slow. The situation is consequently one of inertia so great that rapid change is all but impossible. A major educational effort aimed, in particular, at facilitating a wide dissemination of efficient ways of resource utilization is thus required. Since African national incomes depend heavily on the labour of rural peasants, the need for educating those peasants is accordingly one of supreme importance. The following illustration may convey a feeling of the urgency of this need.

In Tanzania agriculture produces something like 40 per cent of the gross national product; industries produce only about 10 per cent (URT 1980, p 2). This is typical of African economies. So, although dreams of rapid growth usually centre on industries, this sector is nevertheless so small that even if it expanded at the rate of 10 per cent annually, which is extraordinarily fast by any measure, its influence on the growth rate of the economy as a whole would still remain relatively small. Consequently, in Tanzania, as in most of the other African countries, the main determinant of the growth of the economy as a whole for many years will continue to be the growth rate of agriculture. This is why the education of peasants is so important; it is also why their illiteracy is such a great barrier to development.

But the ultimate barrier for most African countries must be their poverty. While in many ways this is a product of the obstacles already mentioned, it is also their immediate cause. African countries are unanimous in wishing to pin most of the blame for their poverty on their trading partners. These partners, they say, have put them in "the straitjacket of consuming what they do not produce and producing what they do not consume, and of exporting raw materials at low and declining prices in order to import semifinished and finished products at high and rising prices" (ECA 1980, p 2). This claim imputes bad blood (certainly bad faith) on the part of Africa's trading partners, and some might wish to dispute its validity. But whatever opinion one may have on this, there can be no denying of the fact that in a world powered by self-interest, as our world in fact is, possession of more handicaps marks one out as a natural prey of those with fewer. And Africa simply has the most handicaps right now. These handicaps include "low income per head, a very high proportion of the population in agriculture, low levels of productivity, a circumscribed and fractured industrial base, a high dependence on a vulnerably narrow spectrum of primary export commodities, a transport network geared largely to the export sector, a sharp bifurcation between the traditional and modern sectors, a high degree of illiteracy, low levels of life expectancy, and a predominance of expatriate business enterprise in banking, commerce, finance, industry and management" (Adedeji 1979, p 59). Because of these handicaps, African countries are experiencing progressive impoverishment instead of steady growth, their great wealth of natural resources notwithstanding. Since these handicaps are not about to disappear, and since Africa's trading partners are not about to become more altruistic than they have been in the past, it is clear that, for a long time to come, poverty will remain an obstacle to African development.

Policies

The obstacle just described may be devided into two groups - those that can be surmounted through the thrust of educational effort and those that appear to be intractable by that method. While each group is of great interest, for the purposes of this article attention must be limited to the former group. The subject of interest is what education can do to ease Africa's energy requirements and what policies that requires. There is special interest in the steps that education needs to take in order top overcome the obstacles Africa faces in the energy sector.

Answers as to what education can, and ought to do, require knowledge of "the initial conditions". Each country must begin by locating itself on the energy-education scale first - that is, by finding out what its schools are currently doing by way of disseminating the required knowledge. This is a major excercise, which will normally involve many subsidiary inquiries as to the existing objectives of education (Are schools preparing students for full lives, based on effective and purposeful interaction with their environment? Presumably, but not necessarily, yes.); or its content (Do current curricula pay adequate attention ot energy? Definitely not.); or its methods (Are present delivery modes satisfactory? Often not.); or its resources (Are teaching staff and school facilities sufficient? Hopelessly not.); or its logistics (Are all the relevant segments of the population being reached? No.) or its links with local reality (Are schools "marginalized" or "peripheralized", in the sense of being alienated from production? Yes.); or its direction (Do educators tend to take their lead from international orientations in education and to disregard causes offered by local exigencies? Yes.); and so on.

When the desired end is more or less known, which would seem to be the case with respect to energy, knowledge of the initial conditions will normally suggest what needs to be done. (When schools are concentrated in towns, where less than a quarter of the people live, a rural-education policy is indicated; when high-level manpower is scarce and its mix improper, intensified and rationalized training is needed; and so on.) However, knowledge of the initial conditions will not always indicate *how* what needs to be done must be done. Essentially this is because the choice of means is always influenced by "extraneous" factors that are not everywhere the same - notably, by the nature and amount of available resources, by differences in visions and in the choice of methods for making them real, and even, simply, by the undeniable haze of uncertainty as to what means best answer a given end. For this reason, different countries will in general adopt different policies.

However, since African countries have in common at least the initial conditions embodied in the obstacles described earlier, several generalizations are possible as to needed future policies. These generalizations are offered here as suggestion of the sort of broad policies that might provide pints of departure for national policies, which, it is realized, require further work, since they have to be tailored to specific factors, whereas what follows is derived only from general considerations.

The first generalization follows from Africa's economic circumstances, from which as has been seen, stem a number of the obstacles cited earlier. In particular, it is an inference from two such circumstances - namely, the dominance in Africa of labour as a factor of production and the present low efficiency levels of African labour. These circumstances point to the need for an improvement of labour in every way and to the necessity of its full utilization. Africa's labour statistics express this need eloquently. It is estimated that open unemployment in urban areas amounts to 10 per cent of the urban labour force and underemployment (40 per cent in rural areas) to a further 26 per cent. In other words, about 30 per cent of the total African labour force (or over 60 million people) are currently unemployed or underemployed. Projections indicate that this will rise to about 39 per cent (over 70 million people) by the year 2000 (Adedeji 1979, p 68). To this must be added the great inefficiency of those "fully" employed, resulting from inadequate training, indifferent supervision, lack of discipline, lack of incentives, absenteeism, and corruption. The sum amounts to so great a waste of energy that, in Africa, energy education must lay its greatest emphasis here. Complete prescriptions for doing this do not yet exist, but several imperatives can already be recognized.

One would appear to be the need to start at the earliest stages of education possible - presumably at the primary level. This has the advantage not only of immediate benefit but also of widest access. (It must be remembered that in Africa 70 per cent of the children do not go beyond primary school.) A second imperative is dictated by the prevalence of agriculture in African economies. This is the need to orient energy education towards agriculture. (Over 70 per cent of the students should, even if they do not always, expect to earn their living on rural farms.) However, school leavers will be attracted to stay on rural farms only be improved working and living conditions, "not by three acres and a hoe"(Lewis 1966, p 109). A third imperative consequently is the need to integrate educational advance within overall development. Without that, school leavers will continue to drift into towns. (Urban populations are estimated to be growing a the average annual rate of 5 per cent, compared to 2 per cent for rural populations (Adedeji 1979, p 68).)

A second generalization has to do with the demand for high-level manpower. Arrangements are needed which have as their aim the provision of the required specialized skills and competence - especially those that are catalytic to the removal of the obstacles mentioned, and including, therefore, those that are likely to lead to discoveries of new sources of energy or to more efficient exploitation of those already in existence. Such arrangements must be preceded by an identification of the skills required and by an estimate of the demand for each. What is likely to emerge from such an exercise is a shortage of persons with technical skills. Consequently, greater emphasis must as a matter of policy be placed on technical education than on general education.

Moreover, training not only must produce skills, but must also produce them in balanced proportion - that is, liberally at the lower levels but more and more conservatively at higher levels. In this pyramid of proportions skills reinforce each other optimally. Certainly the provision of skills is cheaper this way than if the pyramid is invertd. Yet inverted pyramids are precisely what crowd the African landscape. This phenomenon is a consequence of two factors, which any policy seeking balanced skill proportions must take into account: there is, first, the circumstance that abundance of training facilities does not always reflect relative need, and, second, there is the fact that material incentives are usually stacked the wrong way.

The third generalization is a corollary of the preceding two. It is the fact that in order to bring about optimal levels of efficiency in labour utilization, and in order to provide the required specialized skills in balanced proportions, tremendous educational expansion is needed. To convey a sense of the magnitude of the effort required, it is sufficient to draw attention to the disparity between demographic and economic factors in Africa. African children of school age (5 to 15 years) numbered 105 million in 1975, and are estminated to be increasing at an annual rate of 5 per cent. Only 60 per cent of them are currently attending school. So, targetting for full enrollments by the year 2000, say, would mean expanding primary education (to say nothing about secondary, tertiary and professional education) at an annual average rate of 5 per cent (Adedeji 1979, p 67). But, on the other hand, most African countries (excepting the oil producers) have in recent years been able to muster annual economic growth rates, of only about 2 per cent (Kodjo 1979, p 44). For a long time to come, therefore, the demand for education will continue to exceed supply. This points to two policy areas.

One is the need for delivery systems that provide education differently and, above all, cheaply. This need arises from Africa's inability to provide education traditionally and as fast as required. Would students learn any less merely because their classes were held beneath a mango tree? Might staff shortages not be eased by using senior students to teach their junior schoolmates? Couldn't students grow their own food - *fufu*, for instance - thereby reducing the clamour for non-existent funds? And shouldn't each village assume full responsibility for its primary education and relieve the central government of this onerous burden? Countries that have had the nerve to experiment with these ideas obviously deserve praise. However, during unguarded moments, a few of them might be willing to concede that it was all a big mistake. Gallant though these ventures may be, to date few of them can claim conclusive success. After visiting some of these "new" classes, it is difficult not to come away with the distressing feeling of having witnessed pointless exercises in futility: the simplest questions draw rehearsed responses, searching questions blank stares. Quality has so obviously been sacrificed to quantity that no one has to tell you that a few years after school these hordes of mango-tree graduates will show few signs of ever having been to school. And yet before dismissing these and similar attempts completely, one should weigh them against existing alternatives. Often none exist. Thus the first policy area.

The second policy area is curricular reform. At present, in Africa, education is chiefly a mechanism of escape from neglected stagnation in a rural village or unmitigated squalor in an urban slum to "the easy life" of a white-collar job. This view of the aim of education is reinforced in various ways. A popular form of punishment continues, or used, to be one in which the offending student is sentenced to manual work on the school farm. Moreover, teachers like to conjure up the spectre of life in a rural village or an urban slum to subdue unruly students and make them get on with their studies. Nor is this reinforcement really necessary. All students know the grinding drudgery of their parents' life and its stifling lack of opportunities only too well. All they want now is to cut loose and escape from it. That only 10 per cent or less can hope to escape makes little difference. All students want, and receive, an education that is a gateway to white-collar jobs. It matters little that those jobs cannot go even a quarter of the way round.

This obviously must be reversed; curricular reform aimed at the provision of an education suited to the future requirements of the majority must be set in motion. Such reform must of course be the result of careful preliminary inqiry. Here it is possible only to offer illustrative sketches of the shape such reform might take; energy and agriculture provide the background.

At present, African crop yield rates are exceedingly low, a problem that is already serious enough but one which is made even more serious by high crop loss rates (30 per cent (ECA 1979, p 43)). This problem might provide a point of departure for a new curriculum; it could be studied in primary and secondary schools as an illustration of energy input and output. Instead of memorizing tortuous biographies of local dignitaries, students would pass their time more profitably by engaging in both theoretical and practical exercises connected with this problem. Conclusions would then be reinforced by actual comparisons of the yield rates of traditional crops or indigenous animal breeds with those of new and improved varieties. This, of course, will plunge students into precisely the sort of farm routines from which they wish to escape, and the danger is real that their interest could be lost. Consequently, all farm activities have to be a natural, not forced, extension of classroom work. The temptation to turn schools into tools of production, though strong, is to be studiously resisted. Another class activity might be the preparation of "an energy consumption profile" for the surrounding village. Here each student would be expected, for example, to monitor his mother's firewood and kerosene consumption. Yet another class activity might be the compilation of local energy-resource inventories. This activity and others like it would furnish some of the missing data for, and facilitate the formulation of, policies that require it. Further examples of curricular reform obviously can be provided.

No amount of tinkering with the school curriculum will bring much practical change, however, unless it is matched with "bush bonuses" (Dumont 1966, p 200) designed to make school leavers want to stay on rural farms. Changes in school curricula are important, but they are not a decisive factor. Job aspirations are "determined largely by the individual's perception of opportunities with the exchange sector of the economy" (Olutola 1975, p 36). In other words, teach a boy agriculture, and he will still aspire to a clerical job if clerks earn more than farmers. And, in Africa, the popular perception right now is that clerks earn more than farmers. This is illustrated by a recent study made in Nigeria, which found that although 60 per cent of the students polled rated agriculture "highly", less than 3 per cent of *even* these wanted to work in it (Olutola 1975, p 38). Before sufficient incentives for rural farming have been instituted, therefore, expectations that school leavers can be made to return to their rural homes by "doctoring" the school curriculum amount to little more than a wish.

A fourth generalization concerns research, but as the bulk of African research is carried out by universities, the generalization aslo has bearing on higher education generally. It has to do with the fact that African research institutions tend to be mere outposts of developed-world reseach, impressively erudite in problems afflliciting developed countries but remarkably indifferent to those plaguing their own countries. Hardliners consider this to be a consquence of "academic imperialism". Others see "no conspiracy or individual bad faith" about it and consider it to be an effect simply of "the way the system works" (Cooper 1973, p 6). But whatever its cause, there can be no doublt about the need for policies aimed at bringing both research and higher education back in line with local demands.

Tremendous effort is currently being put, for example, in solar energy research, with the aim of devising more and more efficient uses of solar energy for cooking, drying, refrigeration, pumping, distillation, and other functions. This work was pioneerd by, among others, the Institute of Physical Meteorology in Senegal, the Solar Energy Laboratory in Mali, the Institute of Solar Energy and Related Environmental Research in Niger, and the Centre of Energy Studies and Applications in Rwanda (ECA 1979, p 30), but is now being carried out also by many universities. In addition active research is reported to be in progress on windpower (at the Universities of Addis Ababa, Dar es Salaam and Nairobi), lightning power (at the University of Nairobi), biogas (at the Universities of Addis Ababa, Cario, Dar es Salaam, Ife, Kumasi and Nairobi), charcoal and wood stoves (at the Universities of Adis Ababa, Dar es Salaam, Ife, and Nairobi), and geothermal energy (at the Universities of Addis Ababa and Nairobi), and geothermal energy (at the Universities of Addis Ababa, Dar es Salaam and Nairobi) (GTZ 1980, p 141). It is seen that Africa's energy research covers an impressively extensive span. But while this is so, involvement of African researchers in "extension and outreach programmes" designed to deliver the results of their work to potential users is, as a recent workshop of a number of these researchers has had to admit, "generally limited" (GTZ 1980 p 145). Most researchers consider their work done when a report about it is accepted for publication in a "reputable international journal". It matters not that this still leaves potential beneficiaries exactly where they were before.

There are two main reasons for this. One is that such images as universities have of themselves make it unlikely that they will see local problems as being intellectually respectable. This is not only because definitions of intellectual respectability are fashioned in developed countries, but also because technically few of the problems of developing countries are truly "unanswered questions" and thus worthy of university attention, since many of them exist owing more to implementation (including political) difficulties over which the researcher would normally have little control than to a lack of suggestions by the researcher as to what to implement. Perhaps the researcher should seek even simpler answers. However, he then walks an extremely thin line between consequence and inconsequence; it is a path copiously littered with useless engineering prototypes and similar memorabilia. The second reason for the limited involvement of researchers in extension work is that there is little incentive (certainly no financial gain) to spur the reseacher on to taking upon himself also the responsibility of delivering his findings to the potential users. Under present arrangements this additional door-to-door drive must be powered entirely by the researcher's own missionary zeal, with which not all researchers seem to be richly endowed.

In their turn, these two reasons seem to indicate two things. One is that any policy aimed at infusing relevance into research and higher education must devise a system of according recognition and providing material rewards for achievements in what is perceived to be relevant work. Without these bonuses, such policy should not be expected to transcend the level of mere exhortation. The second is that extension and outreach programmes should not be left to the research institutions themselves, if only because such programmes call for knowledge (for example, of the customs, traditions and work habits of the targetted users) that a researcher would not always have. Instead such programmes should be entrusted to organs established for the express purpose of liaising between researchers and their beneficiaries.

Such, then, are some of the factors that policies seeking to align research and higher education with reality in Africa must consider. But are Africa's forays into frontline research really necessary? Obviously they are. There are indications, however, that their importance may be overrated. One recent workshop on alternative types of energy and technology has recommended that "improvement - and adaptation-oriented" research projects should be accorded greater emphasis than "innovation-oriented" activities (GTZ 1980, p 149). Several good reasons could be adduced in support of this recommendation. One is that improvement upon indigenous technology and adaptation of exogenous technology to local conditions obviously do not have to break as many social and psychological barriers among users as totally new innovations do. Another reason is that in Africa innovative research usually smacks of grandstanding pretense, since, in the face of scarcities of resources, one presumably should opt for "proven" methods. Yet another reason is that in Africa innovative research has a tendency to grind to a halt when resource scarcities finally catch up with it and thereafter to turn these scarcities into alibis for not attempting any future research. But the most important reason must be the tendency of African research institutions to leave matters in abeyance, not prosecuting them to their logical finish. As a result of this, innovative research is likely to produce only loose bits and pieces, better suited to serve as input into the well-oiled research machines of the developed world than as contributions towards the solution of local problems. For reasons such as these, then, African countries need to approach "frontline" research advisedly. They should continue participating in the conquest of "new frontiers of knowledge", certainly. But, at the same time, they should curb their enthusiasm and devise policies aimed less at the acquisition of new conquests and more at the consolidation of previous exploits.

A fifth and final generalization is that African educational institutions must not only teach their students, but must themselves learn, to co-operate. Great premium is placed on co-operation because it offers African countries the possibility of pooling resources and achieving economies of scale that individually they cannot attain. Nor are the advantages of co-operation all of this "together we stand, alone fall" variety. Others are a result, not of the fact that co-operation multiplies strength, but of the fact that it eliminates weakness. Research and publications provide one illustration. At present, African research - especially when it aspires to be relevant, or when it ventures into matters on which the government might have a stand - tends to be self-absorbed or to be fettered by unimportant (or even irrelevant) considerations. As might be expected, African journals also tend to have these same weaknesses. As a result, few of them comand much prestige outside the walls of the institutions that publish them. This is one of the reasons African scholars prefer to publish their "serious work" in American or European journals; no author will knowingly condemn what he considers to be important findings to the obscurity of some local journal which his intellectual peers have not even heard of. This obviously poses a serious barrier to African scholarship.

But might it not be surmounted by co-operative arrangements? To satisfy all participating parties, such arrangements would mean, for example, that research objectives and editorial stances must overcome national prejudices, transcend political boundaries, and accomodate a wide range of opinion. This would be a significant gain indeed - even if all it succeeded in achieving was to give research the width of scope and journals the breadth of vision that are sure to win them the international stature they so ardently court. For reasons such as these, and because of the economic advantages described earlier, then, African co-operation is a matter of utmost importance. Without co-operation, African countries will continue to explode into each new decade always with the same problems, which they faced but were unable to solve singly in the previous decade - or the one before.

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15.2

ENERGY AND THE ENVIRONMENT

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Abstract
The objective of this paper is to deal with various world's energy resources, energy producing systems and the effects of dangerous by-products of energy conversion on the environment in which our human civilization is living and will continue to live. A limited survey of the world's energy sources has been presented and various means of energy production and conversion have been discussed. A conclusion has been drawn to the effect that the energy sources are in plenty and can be accounted to serve the mankind's needs. The possible ways in which our environment get affected (polluted) in the process of energy production, conversion and consumption have also been assesed. The physical basis for the waste energy release as a result of the consumption of any fuel and its impact on the environment to which our complex ecological system is sensitive have been reviewed. A comparative study of environmental hazards due to different energy producing systems ensures us, contrary to the lay man's belief, that the nuclear energy is less hazardous and more economical, in spite of the fact that its use demands careful handling, transportation, processing, storage and disposal of potentially hazardous materials.

Introduction

According to an ancient proverb in Hindu mythology every living organism on the earth is made up of five elements, viz. Water, Soil, Fire, Sky and Air, all of which are major sources of energy of modern times. Man, beginning with fire as a source of energy, advanced up to the present nuclear age. During this period of fire to nuclear energy as civilization grew, the need for energy greatly increased so much so that the amount of consumption of energy by a country is regarded as the measure of its degree of technological advancement, which in turn reflects the people's standard of living. Since the world's population is increasing rapidly, the demands for energy to maintain adequate standards of living will continue to grow. Whatever may be the trend, linear or exponential, of the growth of the curve of its consumption with time, energy is bound to remain a central element in our economic and social life. The total dependence on energy has created serious difficulties in terms of the availability of energy and its resources. It, therefore, becomes imperative to explore new and different sources of energy and methods of conversion so as to put them to practical use. But in this process of searching for energy and its utilization, our environment is automatically affected. Although it is true that our enviroment is perpetually receiving energy from the sun which acts as a 'Fusion Reactor' in space, this natural flow of energy is well organized and controlled. However, this natural energy source is not the only one which man expolits. He also derives energy from various other means, such as, Water, Coal, Oil, Gas and Nuclear devices etc. In so doing, man is undoubtedly affecting his environment considerably. This concern for and awareness of the environment further aggravate the energy crisis as it happens to be in direct conflict with the desire for more and more energy.

Thus the question arises, whether the quest for energy should be continued or not, in view of environmental pollution. The answer is obvious - if we are to survive our energy crisis, we must find more resources and choose between different energy conversion techniques so as to diminish impacts on the environment to a greater extent.

The aim of this paper is to discuss the relationship between the deveopment of alternative energy sources and the effects these will have on the environment. It will survey the various energy resources and their potential hazards to our environment in the process of energy production and conversion.

Energy resources

About a century ago, wood was the principal source of energy. With the passage of time, fossil fuels took its place and are playing a dominant role in energy supply even today. In addition, there are many other energy sources which are of paramount importance. A whole array of world's energy sources can broadly be classified in the following manner:

Depletable; Non-Depletable; Renewable; Non-Renewable; Solar; Gravitational; Fossil Fuels; (Coal, Oil, Natural Gas, Oil Shale and Tar Sands; Nuclear; Geothermal; (Fission & Fusion); (Wind, Ocean heat, Solar thermal and Organic wastes); (Tidal and Water).

However, this classification is purely academic because, for example, the time scale for regeneration of fossil fuels is too long for these to be treated as renewable. Likewise, for geothermal energy, resource is estimated as the heat stored in the outer shell (about 10 Kms depth) of the earth at a temperature usually above 15°C and this stored heat is definitely renewable, in due course, through the flow of heat from the core to the outer shell of the earth. Similarly, in the case of non-depletable energy sources, a clear distinction between the solar and the gravitational energy forms is simply not possible because of their strong mutual dependence. Also, the rate of consumption of some of the sources is so fast that they appear of be depletable but because but because of their regeneration time being very short these, in fact, are considered as non-depletable.

I shall now briefly review each one of these sources separately.

Coal

The reserves of Coal are considerably greater than those of other fossil fuels and are estimated to be adequate for about 100 - 400 years. The world's Coal reserves, as estimated (Averitt, 1969), are shown in Table 1.

Table 1: Total Original Coal Resources of the World

Continent	Resources by Mapping and Exploration (10^9 short tons)	Probable Additional Resources (10^9 short tons)
Asia and European USSR	7,000	4,000
North American	1,720	2,880
Europe	620	210
Africa	80	160
Oceania	60	70
South & Central American	20	10
Total	9,500	7,330

Although the coal deposits are virtually world wide, the extraction is not so simple and economical. The problem of controlling all gaseous emissions and the development of effective mine safety measures are yet to be solved. However, in recent past years, due to acute shortage of energy there has been a world wide response to increase the coal production. The U.S.A. and the U.K. both have already proposed to expand their coal industries by many fold in the near future.

In order to meet the future energy supply demands, the technology must be developed to enable coal to be used as an appropriate source of energy even in twentieth century.

Oil

At present about 70% of the world's energy requirements are met by the petroleum. All world's oil resources including condensate are estimated (Styrikovich, 1976) to be about 3 trillion tons. Of this, about 1 trillion tons are within the continental part of the globe, 0.5 trillion tons are in the Oceanic shelf areas (about 500 m depth) and 1.5 trillion tons are in the deep water regions.

In terms of proved reserves, Middle East has 53% of the world oil and U.S. including Alaska only 5%. It is important to point out that during past 30 years, the proved recoverable reserves in the U.S. have doubled while its percentage of the world's proved recoverable reserves has steeply decreased.

A very significant difference exists between the estimated amount of oil at a place under the ground and the actual amount which can be recovered. This is so because the oil in the ground is contained in porous rocks and, therefore, the flow depends upon the porosity of the reservoir rock and also on the viscosity of the oil itself. Oil is recovered from the oil field mainly by three methods commonly known as Primary, Secondary and Tertiary methods. The Primary method refers to the one in which oil runs to the well from the surroundings due to pressure and gravity effects. It amounts to the recovery of about 30% of the total oil in a particular place. In case of Secondary recovery, the oil field is flooded with water which tends to float an additional amount of oil out of the media and makes further an additional of about 10%. Any other methods which are used to increase this yield further to an extent of about 12% fall under Tertiary method. There are several tertiary methods to date and researches are going on to make them more economical.

Natrual gas

Natural gas is the by-product of production and has been in abundance until recent years. It is a popular source of energy due to its controlled low price and cleanliness in burning. The estimation of natural gas resources is rather difficult as it occurs in two different conditions, such as, 'Associated gas' and 'Non-Associated gas'. Associated gas is the one which remains in contact with or gets dissolved in the crude oil at very high pressure, while the Non-associated gas occurs without any contact with crude oil. About 80% of the natural gas available at a place is considered to be economically recoverable.

As quoted in the literature (Styrikovich, 1976), the world resources of natural gas exceed 1600 x 10^{12} cubic meter at normal temperature and pressure (nm^3), i.e. about 2 trillion tons of hard coal equivalent (h.c.e.). Of these, about 500 x 10^{12} nm^3 belong to the continent, 200 x 10^{12} nm^3 to the shelf and about 800 x 10^{12} nm^3 to the deep water areas. But the economically withdrawable resources of natural gas has been estimated (Styrikovich, 1976) to be about 1 trilion tons of h.c.e. As mentioned earlier, these estimates are not considered to be very accurate. Further, the combined economically withdrawable reserves of oil and natural gas are as large as 2-3 trillion tons of h.c.e. and can last up to the year 2000 at the expected rate of world energy balance and growth.

Shale oil

Shale oil is one fossil fuels energy source which has not yet been commercially exploited. More than two-thirds of the total world deposits of oil shale are in United States. High quality deposits contain, as estimated (Shepard, 1976), 590 x 10^9 barrel (bbl, 1 bbl =42 gallons). A major portion of this can be utllized economicaly. Besides this, there are lower grade deposits also which contain about 1150 x 10^9 bbl. In the absence of cheap technology, this source of energy is not being utilized extensively. But, in view of growing needs and costs of energy, efforts are under way to make it more economical.

Tar sands

Tar-sands are not very widely distributed as compared to other fossil fuel deposits. These are roughly one-third of the total oil shale reserves. Most of the Tar sands deposits are in African continent. Also a quite substantial amount (about 25% of the oil deposits) exists in Canada and relatively less, about 2% of the Shale oil deposits, in the U.S.A. These represent about 5% of the world oil deposits.

Nuclear energy

It is such a versatile source of energy that the solution of the present and the future energy crisis may possibly be attributed to it. There are two different phenomena, Fission and Fusion, which govern the production and the use of nuclear energy. In both, Fission in which a heavy nucleus splits into two or more fragments; and Fusion in which two very light nuclei combine together to form a heavier nucleus, more stable elements are produced and an enormous amount of energy is released.

Fission: There are mainly two naturally occuring elements, Uranium (U) and Thorium both occur in nature in the form of their oxides, i.e. U_{38} and ThO_2, respectively. The estimated (OECD, 1973, IAE Tech. Rep. , 1966) world's reserves of Uranium and Thorium are given in Table 2. These data are exclusive of resources of U.S.S.R. and China. A major portion of world Uranium deposits is in U.S.A. followed by Canada.

Table 2. Fission Energy Resources

Uranium	2.3 x 10^6 tons U_3O_8	1.95 x 10^6 tons U
Thorium	2.4 x 10^6 tons ThO_2	2.11 x 10^6 tons Th

The actual fissile material that is used in light water reactors is ^{235}U, an isotope of Uranium, which is only 0.7% of the natural Uranium. The remaining 99.3% is ^{238}U which is not readily fissionable. Thus, the total world ^{235}U content is 5.6 x 10^4 tons. Using Breeder reactors the most abundant isotopes ^{238}U of natural uranium and ^{232}Th of thorium can be converted into ^{239}Pu and ^{233}U, respectively, which are again highly fissile and produce tremendous amount of energy. To have an idea of the energy produced, it is worth noting that when a single ^{235}U nucleus fissions the energy released is about 200 MeV.

Fusion: The possibilty of obtaining energy through this process was stipulated as early as 1929. Light nuclei such as Deuterium (^2H), Tritium (^3H) and other Hydrogen isotopes are main soruces of this energy. The total deuterium of the world is estimated (Denton, 1976) to be about 51.6 x 10^{12} metric tons. As regards tritium, it is obtained from neutron reactions with ^6Li, an isotope of Lithium.

As estimated (Hubbert, 1969), Lithium resources of U.S., Canada, and Africa are 19.6 million metric tons (mmt) of Li_2O or 9.1 mmt of Lithium. This amount is exclusive of lithium from sea water (about 0.1 ppm) and from the earth's crust where its abundance is 20-32 ppm. However, it is not very practical to extract these amounts. The useful isotope for fusion, as mentioned earlier, is ^6Li which occurs as only 7.42% of lithium metal. Thus, the amount of world estimated ^6Li comes out to be about 67.5 x 10^4 metric tons.

Two of most important fusion reactions are deuterium $\rightarrow$ deuterium (d,d) and deuterium $\rightarrow$ tritium (d,t) reactions.

As compared to fission, fusion has several advantages. The potential hazards are almost negligible comparatively. Fusion, if controlled properly, can assure us a permanent and relatively safer supply of energy.

Geothermal energy

Geothermal energy makes a very small, but locally important, contribution to the world energy crisis. The origin of this energy actually lies in the hot interior of the earth. The earth's total heat content is enormous (about 10^{35} Cal); nearly all of it is inaccessible to us. On an average, only 0.063 watts/m³ of energy is conducted to the surface. However, geothermal areas, where this flux is much higher, can provide 60 million Kw of electric power for decades. The world geothermal energy stored in various forms (White, 1965, and Muffler & White, 1972) is shown in Table 3. These estimates are exclusive of the thermal energy stored in areas of normal temperature gradient.

Table 3. Geothermal Energy Resouces

Type	Depth	
	3 Km	10 Km
Convective hydrothermal	2×10^{21} Cal.	10^{22} Cal.
Magma, Geopressure and Impermeable rock		10^{23} Cal.

All World estimated geothermal energy resources can possibly produce electricity of the order of 300×10^9 KWh/yr, which is equivalent to about 100 million tons of conventional fuel per year.

In principle, geothermal energy can be tapped from any point on the earth simply by drilling deep enough holes to privide a passage for the heat transfer fluid. The present drilling technology is limited to about 1200 meters, while the base of the continental crust where the temperatures reach 1000° C varies from 25 - 50 Kms in depth. However, in the regions of active volcanoes, geyser fields and hot springs, it is a matter of only a few hundred meters from the surface of the earth.
Geothermal energy has already been exploited for the generation of electricity at many places, such as Larderello (Italy), Wairakei and Kaweran (New Zealand), California (U.S.A.), Namafjall (Iceland), Mexico etc., where the geological formation favours the natural release of steam.

Tidal energy
Tidal energy is a less conventional but virtually inexhaustible natural source of energy. It is the mixture of both kinetic and potential energies produced as a result of interactions among Earth, Moon and Sun. The potential energy is associated with the separation of these three bodies, where as the kinetic energy is associated with the rotation of these bodies about each other and about their own axes. The earth converts some of its potential energy in to kinetic energy through ocean tides which is caused by the gravitational attraction of the moon on the earth's water. This converted energy is dissipated in the form of heat energy through frictions.

According to an estimate (Munk and MacDonald, 1960), based on astronomical data, the total rate of tidal energy dissipation on the earth is 3.2×10^6 megawatts (MW). A major fraction of the dissipation occurs in the open oceans, areas of low tides (about 1 meter high). High tidal areas (about 1-10 meters high) are bays and estuaries. An estimate (Hubbert, 1969) gives the average tidal potential power as 63, 775 MW and the potential annual energy as 560 million MWh.
There are already several modern tidal mills under operation, especially in France, England, U.S.S.R. and, of course, one here in Rhode Island, U.S.A.

Water Energy
This form of energy is not characterised by its reserves but by the possible amount of energy it can produce. When a stream is dammed a large reservoir is formed. The water, thus collected, is made to fall from certain height to turn a hydraulic turbine coupled to an electric generator and the hydroelectric power is produced. The power produced at any station is proportional to the rate of flow of water times the vertical distance through which it falls. Another method which is commonly known as 'The Pumped Storage Technique', in which turbines are used to pump water up to a reservoir, is not considered to be very economical.

The total world power capacity is 2.857×10^6 MW (Hubbert, 1969) of which the 1969 installed capacity of the world was 274,700 MW (U.S. FPC, 1972). Thus, the world's water energy resource is about 25×10^9 MWh annually. The future of this energy in Europe and U.S. is not very bright because of a high degree of exhaustion of economically acceptable hydraulic resources, but it has still got a potential scope in Asia, Africa and South American.

Wind energy
At one time wind energy was an important source of energy, particularly for cornmills and irrigation, and recently it has been regarded as useful in strong windy regions. It has the great advantage of being self-renewing energy resource which can supply a continuous non-polluting energy for an indefinite period.

The origin of this energy lies in the fact that about 30% of the incident solar energy never reaches the earth's surface and is absorbed by the atmosphere which, while in circulation due to the pressure difference between various regions, provides wind velocities up to 200 mph blowing at altitudes between 20,000 and 40,000 ft above sea level. As regards the generation of electrical power, it requires wind direction and velocity to be fairly constant over long periods and, of course, there are many locations where these conditions prevail.

A simple derviation shows that the wind power varies as the cube of the wind speed which means wind generators function non-linearly at high wind speed and generate tremendous power exceeding the rated value of the generator itself. Also there is a certain minimum value of the wind speed required to trigger the operation. Thus, for the proper functioning of the generator the wind speed is regulated within these limits.

According to an estimate of the World Meteorological Organization (WMO Tech. Note, 1954), atleast 2×10^7 MW of electrical power can be generated from winds, and the world's wind energy resource is about 175×10^9 MWh annually.

Ocean heat energy
It is well known that a major portion (about 71% or about 140 million Sq. miles) of the earth is occupied by the sea whose average depth is 2.5 miles. The total volume of water in the ocean is roughly 350 million cubic miles. Since this enormous volume of water is constantly receiving the Sun's heat (for every 1°F of temperature rise, one cubic mile of sea water absorbs 2.69×10^9 KWh of energy), the surface temperature of the ocean water in tropical areas is as high as 27° C as compared to that of 4° C at depth as little as 300-400 ft at the equator. This difference in temperature between the surface and the deep ocean water is utilized to operate a heat engine which in turn produces electrical energy. Gulf stream areas are particularly more favourable for producing this form of energy.

There are several sites (Denton, 1976) through out the world, such as Gulf of Florida and the Caribbean sea and off Central America, East and West Africa, Arabia, Ceylon, Indonesia etc., where possibilities for harnessing this energy have been envisaged. An annual electric energy production of 26 x 10^9 MWh (Denton, 1976) is potentially available in the Gulf of Florida. Assuming the world potential as 10 times that of the Gulf of Florida, the world energy resource from this energy comes out to be 260 x 10^9 MWh annually.

Solar thermal energy

Solar energy is a very powerful and continuous source of energy. The origin of this energy is the thermonuclear reaction (Fusion) in the Sun in which hydrogen is fused to form helium. It arrives at the earth's atmosphere in the form of radiant energy. Only two-thirds of this extra-atmosphere solar energy arrives at the surface of the earth. The rest of it is lost in the passage through the atmosphere as a result of its interaction with clouds and molecules present in the atmosphere. The total solar power level has been estimated (Denton, 1976) to be 3.86 x 10^{20} MW. Because of the huge distance (about 150 million Km) between the Sun and the Earth, the solar power arriving outside earth's atmosphere is reduced to 1.36 KW/m^2, with a spectral distribution resembling that of a black body radiator at about 5800° K. This solar power, during its transit to the surface of the earth, is further reduced by a factor of two-third and remains only about 1 KW/m^2. Considering other climatolgical factors, the total annual mean daily solar insolation is about is about 4.0 KWh/m^2 per day. This average value is possible applicable to about two-thirds of the earth's surface which yields a total world solar energy resource of about 500,000 x 10^9 MWh annually.

Although already in use, its use on a large scale poses serious economic difficulties. As yet, its use has been confined to limited areas, such as room heating and cooling, domestic water heating, growth of fuel crops, small scale electricity generation etc. The main problem in the practical utilization of solar energy on a large scale is its initial collection and storage in the form of heat. The collector on receiving Sun's radiant energy raises its temperature and transfers heat to a storage medium. During this process a considerable amount of heat losses take place making difficult the achievement of equilibrium temperature of the collector. Large-scale utilization of this energy appears to be remote unless some technological break-through occurs.

Energy from organic wastes

The energy content of the organic solid waste is considerable. There are several ways in which energy can be extracted from it. The simplest and the best way is to produce methane from it. In fact, this occurs naturally and is trapped by Sewage disposal plants to produce heat. It has been found that 1 ton of solid waste is sufficient to produce 10,000 cubic feet of methane, which in turn yields 10^5 Btu of energy. Another main consituent of the organic waste is the Carbon. If the major content of the organic waste happens to be news papers, it provides plenty of Cellulose carbon from which fuel oil can be extracted. The process is simple in which the waste is heated at high temperature and pressure in the atmosphere of Carbon-monoxide and steam. By this technique about 99% of the Carbon content of the waste can be converted into fuel oil. Thus, the production of oil and the disposal of waste material take place simultaneously, making the process very economical. This is already being practised in the U.S.A.

There are several other methods available for the fermentation of organic wastes to produce materials like ethanol, butanol, acetone, ect. These methods, although developed earlier, have proved economical in recent years due to tremendous increase in oil prices. In India, already the ethanol produced by the fermentation of plant materials is being used in the commercial production of polyethylene. In tropical countries, particularly in Africa and South America, a substantial amount of energy can be produced by fermenting the vegetations which are in plenty and being used for nothing.

Thus, the waste materials which do not only provide fuel but also keep our surroundings clean are good supplement to our energy sources.

The conversion of energy

It is a well known saying that energy is neither created nor destroyed but can be converted from one form of it to another. Energy always remains hidden in its sources in the form of potential energy. To put to use, it needs to be converted into kinetic energy which is utilized mainly in the forms of electrical , mechanical and thermal energies. Electrical energy being the most important of all, controls almost all our activities in life. Mechanical energy handles two tasks which electricity does: it produces movement and heat. It can also generate electricity with an efficiency of 90-95 percent. Winds, tides, flowing water etc. are main sources of mechanical energy in nature. The third one is, of course, the thermal energy in the form of enormous heat in a confined space. It is produced by burning fossil fuels or by nuclear fission and fusion. It can be converted into mechanical energy which in turn can generate electricity.

Electricity being the most important secondary source of energy, my main objective here is to discuss conversion processes by which it is produced. The most important of all is through the use of 'Steam Turbine'. Other sources are Water turbines, Gas turbines, Diesel engines and Magnetohydrodynamics. I shall briefly discuss only the principle involved in the Steam turbine as the relative importance of the rest of sources is very small.

Steam Turbine

It consists of a special type of 'burner' in which the fuel is burnt. The heat released as a result of the combustion of fuel is extracted in the boiler. This accumulated heat in the boiler is used to produce steam at a temperature as high as possible. The steam thus produced drives the turbine and then passes to the condenser. On reaching the condenser, the steam gets condensed to water and returns back to the boiler. The turbine drives an alternator whose output is transformed to high voltage and is made available for use. Based on the principle of operation of the Steam turbine, various power plants function and generate electricity using fossil fuels or nuclear fuels.

Fossil Fuel Power Plants

In such power plants, heat is produced by burning Coal, Oil or Natural gas. Coal being in abundance and cheap is preferred over the last two. Coal, in pulverized form, is blown into the furnace which is the main interior of the steam generator. The gases produced as a result of the combustion of coal have temperatures in excess of 3000°F in the combustion region. These gases radiate heat to the furnance walls as they pass through the interior of the steam generator and get cooled. At last these gases are allowed to reach the exhaust stack and hence into the atmosphere, still at a temperature of around 500° F. The furnace walls of the steam generator consist of pipes containing water to produce steam when heated. The steam so produced enters the superheater, a heat exchanger consisting of banks of tubes, where it is heated up to 1000°F-1150°F and is allowed to flow back to the turbine to continue its expansion. The steam turbine utilizes the energy in the steam to drive the electric generator which in turn generates electrical energy with an alternating current.

Nuclear Power Plants

The principle of operation of both the nuclear and the fossil fuel-fired plants is essentially the same with only the exception of the steam generating unit. In a nuclear power plant, the conventional steam generating unit containing the furnace is replaced by the nuclear reactor and the rest of the cycle elements remain almost the same.

I will now discuss, quite briefly, various nuclear fuel cycles which govern the conversion of mass-energy into electrical energy in a nuclear power plant. The cycles are as follows:

(i) The *BURNER* makes use of only highly enriched (93%) Uranium in the isotope ^{235}U. A large amount of ^{238}U is discarded, and, therefore, the consumption of natural uranium becomes excessive. It is also called Light Water Reactor (LWR) because, in it, ordinary water is used both as a 'coolant' to transport the heat released in the fission and as a 'moderator' to slow down fast neutrons produced in the fission. Reactors of this type are used for very special purposes, e.g. Propulsion of Submarines and Space Vehicles.

(ii) The *CONVERTER*makes use of slightly enriched (2-3%) Uranium in the isotope ^{235}U with ^{239}Pu produced from ^{238}U in the reactor fuel. There are two types of this reactor, one is the natural uranium fueled heavy water reactor (HWR) which does not need the enrichment process, and the other is the high-temperature gas-cooed reactor (HTGR) which requires enriched uranium only as a starting fuel. In such reactors, Helium gas is used as a 'Coolant' and the Graphite as a 'Moderator'. Further, when the discharged ^{239}Pu from the reactor is fed back into the reactor to start recycling process, the reactor is called 'Converter With Plutonium Recycle'.

(iii) The *BREEDER* uses the natural Uranium (^{238}U) as a fertile material to reproduce ^{239}Pu, a fissile main fuel for the reactor. The isotope separation is not required and the recycling of ^{239}Pu is done. This reactor also uses ^{233}U as fuel and breeds it. The ^{233}U is produced from ^{232}Th, another fertile material. It is also a gas cooled and Graphite-moderated thermal reactor, and is the most efficient of all reactors.

(iv) *D-T FUSION REACTOR* would be based on the production of energy (heat) using the D-T reaction. The deuterium separated from ordinary Hydrogen in water and the tritium produced by neutron bombardment of ^{6}Li can be used as fuels.

Conversion of Solar Energy to Mechanical Energy:

Since the efficiency of a heat engine depends upon the temperature range over which it operates, heat engines driven by solar energy will be extremely inefficient unless considerable concentration is used to increase the equilibrium temperature of the collector. Detailed studies show that until the concentration ratio is about 20, the temperature does not reach the 645°K of a nuclear power station for an insolation of 400 W/m^2. Even at this temperature, the maximum possible conversion efficiency from heat to mechanical energy happens to be only 35%.

Using solar energy as a source of heat, it is possible to produce refrigeration and air-conditioning. The method is simple in which the refrigerant (e.g. Ammonia) is dissolved in another fluid (e.g. Water) at a low temperature. This is then pumped to a high pressure and the fluid is separated by heating. Heat is then removed from the refrigerant in a condenser, the refrigerant is expanded back to low temperature and pressure and redissolved in the carrier fluid. Although the efficiency of this process is low compared to the usual compression cycle, it is very simple to operate.

Conversion of Solar Energy to Electrical Energy:

There have been several approaches, but none economial to date, to the problem of converting solar energy into electricity. The fuel in this case is free, the cost of the power depends on the cost of the system responsible for the conversion of sun light to electricity. Presently, the electricity produced from solar energy is 100 times more expensive than that for coal fired thermal power plants.

As revealed earlier, in conventional power plants, fuel is burnt to produce heat; the heat is converted into mechanical energy and then to electricity. The conversion from mechanical to electrical stage is almost without any loss. But, in the case of solar energy, limiting factors are collection of heat and its conversion into mechanical energy. The area of the collector necessary for power generation on a commercial scale is really formidable. A plant of 500 MW out put, at 600 W/m^2 insolation and an efficiency of 30%, requires a collector area of about one square mile. Also for a corresponding high concentration ratio, the entire collection area must be capable of tracking the Sun. This makes the problem techanically difficult. A further limitation to this is caused by the intermittent nature of the energy supply.

Thus, the cost and complexity of conventional solar power plants, except for domestic and small installations, compel us to look for other methods for solar energy conversion to electricity. There are, however, two methods:

(i) Thermoelectricity - direct conversion of heat collected from the Sun, and
(ii) Photelectricity - direct conversion of the Sun Rays. Detailed description of these two methods will not be taken up here as it is beyond the scope of this article.

Environmental aspects of energy use

Energy from any source, before it is available for use, has to be produced and converted into an appropriate form such as electrical, mechanical, thermal etc. During the process of production, conversion and even consumption of energy, the environment around us is affected. In broader sense, the pollution caused by the power can be visulaized in two ways.

The first is the pollution associated with the extraction and the transportation of the fuel material - coal mining can lead to land erosion and subsidence, while off-shore drilling and the transportation of crude oil can pollute oceans. Secondly, the production and conversion of energy from fuels in consumable form - during the process of power production from fossil and nuclear fuels, discharge of gases and radioactive materials, respectively; and vast quantities of waste heat from both, take place into the environment. The waste heat causes thermal pollution. I shall now discuss these pollutions under three major heads as shown below:

Extraction and Transportation of Fuels:

Of all fossil fuels, coal is the most potent pollutant and is in abundance. Coal is mined in a variety of ways. However, there are two main techniques, 'Underground' and 'Open-cast' or 'Strip' minings. Strip mining is popular in terms of costs and productivity but the damage caused to the surface of the earth is much more compared to that in underground mining.

Strip mining is practised on both flat land and mountain sides. In flat regions, it is called 'Area Strip Mining' in which the soil above the coal (overburden), in a long trench, is removed by a power shovel and the coal is extracted. A parallel trench is then dug and the overburden from this one is also removed and deposited in the region of the first cut. When this is continued, in course of time the land is transformed into a series of ridges and gullies which are susceptible to erosion by wind and rain. Strip mining, when practised in mountain sides, is called 'Contour Strip Mining'. This type of mining is carried out when there is a coal seam in hilly areas and is more destructive. The overburden removed by the first cut is discarded down the hill side and the coal is extracted. The power shovel is then moved in towards the center of the hill and successive cuts are performed, resulting in the removal of more overburden. The mining follows the contour of the hill and is continued till it is economical. The overburden thrown down the hill is the major cause of damage. It is easily eroded and washed into the flat areas and streams below. Also such a tumbled land causes failing of boulders and frequent landslides which in turn cause considerable damage.

In underground mining, the main problems is of subsidence when the coal left to support the overburden is not sufficient. This particularly poses problems in urban areas where the disturbance can cause damage to streets and buildings. In rural areas, it can make the land unusable for crops, construction of dams or reservoirs etc. and can damage drainage systems. Also another important factor is the fire in operating as well as abandoned mines. The fire causes depletion of coal reserves, destruction of vegetations and the emission of dangerous gases into the environment. Futher, a very serious damage results from abandoned mines when the water reaches the remains of coal seams. It reacts with the Sulphur containing Pyrites to form Sulphuric acid, a destructive pollutant, harmful to the aquatic life and vegetations which are very sensitive to its acidity. In addition, when this contaminated water interferes with the water used for municipal supplies, industries, cooling etc., it becomes detrimental to the public health. During transportation, tiny coal fragments are discharged and spread in to the environment through wind and cause pollution. A dreadful disease known as 'Black Lung' is very common among miners. It occurs as a result of inhalation of coal dust and affects lungs and breeds several respiratory diseases.

Pollution from oil is very hazardous and results at all stages in its journey from well to combustion. During the process of digging wells, some times, poisonous gases are emitted which, if not properly handled, cause damage to human life and the environment. In addition, according to a source (SCEP, 1970), in 1969, out of total world oil production of 2700 Mt, when 1200 Mt was transported by tanker, the total loss into the ocean was about 2.1 Mt. Thus, the major source of oil pollution during its transportation is accidental spills in off-shore waters. The crude oil contaminates the sea water and kills marine organisms. Petroleum hydrocarbons can cause mass destruction of the food sources of higher species.

Conversion of Energy from Fuels:

(i) **Discharge of Gases:**

The combustion of fossil fuels, in power plants, results into the emission of different kinds of dangerous gases. Most hazardous are, Carbon monoxide, Carbon dioxide, Sulphur oxides and Hydrocarbons. Other variable gases such as Methane and Ozone are also potential pollutants and cause unwanted effects on our environment.

Carbon monoxide is one of the major pollutants of the environment and is produced in large quantities as compared to other pollutant gases. It is produced as a result of incomplete combustion (in the presence of insufficient oxygen) of carboniferous fuels in auto vehicles, heating, industrial processes, refuse burning etc. Automobiles are supposed to be the major sources. The total global emission of Carbon monoxide has been estimated (Robinson and Robbins, 1968) to be 200 Mt per year. It is odorles sand poisonous in high concentrations. It replaces and occupies the place of oxygen in hemoglobin, thereby making the red blood cells inactive. The iron atoms in the hemoglobin are also greatly affected (about 200 times more than oxygen) by it.

Carbon dioxide influences the climate more rather than harming the man and organisms directly. The burning of fossil fuels produces several billion tons of Carbon dioxide into the atmosphere each year and the rate is increasing fast because of the increase in fuel consumption

Earth receives radiations of high frequencies (short wavelengths) from the sun and radiates at long wavelengths. Carbon dioxide, being transparent to radiations of short wavelengths, does not change the incoming flux. But, it does capture a portion of radiations (long wavelengths) that are radiated out from the earth. The net effect of this is to increase the temperature of the atmosphere. Calculations show that a 10% increase in the temperature of the atmosphere causes a 0.2° C rise in its temperature. It is interesting to note that from the late nineteenth century until about 1940 there was a gradual warming trend to an extent of about 0.6° C, but in the last 30 years, there has been a 0.2° C cooling. These fluctuations in the temperature may appear to be small but greatly affect the climate. The cooling trend has not yet been explained fully. However, some scientists attribute it to the presence of another pollutant, 'Dust', in the atmosphere, which is scattering solar radiations back into space, thereby reducing the incoming flux, and, therefore, the heating, at the earth's surface.

Almost all fossil fuels contain Sulphur. Oil contains 0.5-2% and the fuel oil which is used in power plants contains about 1.5%. The natural gas is practically free of this element. Coal is the major content of Sulphur, about 0.2-7% by weight. When these fuels are burnt, in a power plant, sulphur dioxide is formed. The total world emissions (Robinson and Robbins, 1970) of sulphur dioxide, in 1965, were 130 Mt of which 70% was due to coal burning and 16% to oil burning. The rest came from other soruces. Sulphur dioxide is a very potent pollutant and is spread in the atmosphere by a number of ways. In the absence of proper emission controls, it has been found that the sulphur oxides produced from burning of 10 million tons of coal in a densely populated area causes about 2000 cases of respiratory diseases in children below 5 years of age, and about 2000 early deaths in people over 60 years. When sulphur dioxide when comes in contact with water, it reacts and forms sulphuric acid which when inhaled affects respiratory system and lungs. In addition, because of its presence in the atmosphere it easily gets mixed with rains and becomes more acidic, and, therefore, injurious to aquatic life and plants.

Hydrocarbons are mainly produced from automobile fuels but they can also by produced in any burning process. They react with oxygen in variety of ways and produce dangerous compounds.

Oxides of nitrogen are produced in fuel combustion at very high temperature. These oxides are spread in the atmosphere very rapidly and are removed also soon as a result of vapour-phase absorption by water to form nitric acid.

(ii) **Discharge of Radioactive Materials:**

All nuclear power plants produce radioactive waste as an essential by-product. But, the main source of radioactive pollution is the fission reaction itself. Nuclei produced (fission products) in the fission process are highly unstable and decay through mainly beta and gamma ray emissions, and form a chain of radioactive nuclides. Some of these nuclides are shortlived (intense) and, therefore, more dangerous than those long-lived ones. Radiations produced in their decay have serious biological effects. They interact with living body tissues, cause damage to cells, and produce what are known as 'Somatic' and 'Genetic' effects if exposed for longer duration.

A reactor produces radioactive pollution in all the three forms, solid, liquid and gaseous. The most hazardous solid wastes originate in the fuel reprocessing plant rather than the reactor itself. Fuel rods, after being inuse for a year or so, need to be replaced by fresh ones. These rods are, therefore, transported by road, in special containers, to the fuel processing plant. These used rods being highly radioactive, if spilled in case of an accident during transit, can contaminate the environment drastically.

However, on safe arrival at the processing plant, these are chemically processed in order to extract the useful material and to leave the radioactive waste. The short-lived constituents of this radioactive waste are safely sorted out and discharged into the sea. What remains, high-level wastes, are real pollutants. They are mainly ^{90}Sr, ^{99}Tc, ^{137}Cs and ^{238}Pu, fairly long-lived (half-life several hundred years) elements and must be stored somewhere for hundreds of years in complete isolation from the environment.

Breeder reactors produce ^{239}Pu, from neutron reaction with ^{238}U, which is very long-lived (half-life 24000 years) and one of the most dangerous of all radioactive elements. It is highly toxic, affects respiratory system, and causes lung cancer. It helps in clandestien nuclear bomb making and while in the hands of terrorists, raises several complications.

The most important category of radioactive waste accumulating during maintenance and fuel reprocessing operations is the highly active liquid (water) waste. It contains 99% of fission products and a high proportion of transuranic elements, except Plutonium. After removing short-lived pollutants from this, it is held for some time and then released slowly into the cooling water of the steam turbine. It then gets mixed with this large quantity of water which is finally channelled to river of lake. Thus, radioactive materials, of course, in a very small proportion are released into the environment.

The release of gaseous radioactive materials is only important in the case of Boiling Water Reactors (BWR). The steam in contact with the core of the reactor carries with it some of the gaseous fission products, such as nitrogen, iodine, krypton and xenon. Most of these gases are removed by conventional means. The pollutants which are of most concern are, ^{85}Kr, a noble gas (half-life 10.7 years) and Tritium (half-life 12 years). Since both of them are relatively long-lived, these materials will accumulate in the environment.

The contribution of fusion reactors to the environment in the form of dangerous radioactive materials would be almost negligible and would not cause any concern.

Waste Heat Release:

All power plants (Thermal, Fossil fuels and Nuclear) in the process of electricity generation release a large amount of heat. Qualitatively it is such a low-grade energy that it is called 'waste heat', but quantitiatively it is about 65% of the total energy produced by the plants. This waste heat energy is dissipated into the environment in variety of ways. The most efficient way is through the use of water. In all power plants, as pointed out earlier, water is used to cool their condensers. Water is taken in from a river, is heated and then discharged downstream from the plant. Since this water is hotter than the rest of the river's water by 10-30° F, it is less dense and stays on the surface. It spreads out from the original place of discharge and loses its heat energy to its surroundings through radiation, conduction and convection processes. This hot water is the major source of thermal pollution and greatly affects our ecological system which is very sensitive to changes in environmental conditions. Waste Heat, besides causing pollution, has a few beneficial uses also.

Hazards

An increase in the river's temperature causes decrease in its oxygen content. But at the same time higher temperatures increase the rate of metabolism of animals living in the water, doubling roughly with each 10° C rise. The need for oxygen also goes up in proportion which affects the chances of survival of animals. Higher temperature is lethal for fish because it reduces the affinity of fish blood hemoglobin of oxygen, thereby making the growth faster and life span shorter. The upper lethal temperature limits range from 160° F for tropical fish to 77° F for salmon and trout. Also the increase in temperature of the water affects the assimilation of the organic wastes dumped into it. Since the assimilation is governed by oxidation, the decrease of oxygen lowers the water's ability to process its sewage load.

The rates of growth of plants such as algae depend on temperature and is particularly favourable when the heat sink is a lake. The appreciable difference in temperature between the bottom (cold) and top (hot) layers accelerates the rate of stratification of the lake and, since the bottom waters are usually richer in nutrients, it increases the algae growth in the warm surface layer.

If the excessive temperature region is too large, the normal path of highly mobile animals in the water is seriously disturbed. The migration may take place earlier or later than normal schedule, which can affect the chances of their survival.

The increase in temperature some times, especially in colder climates, may be desireable also. The abundance of fish has been noticed quite often at power plants condenser discharge point, which is possible due to the increase in plant food supply at that point.

In addition, since chlorine and DDt are used in the cleaning of the condenser, these chemicals get mixed and react with water. The rise in temperature of the river's water accelerates the rate of chemical reactions, as a result water becomes more toxic and poisonous for aquatic life in general. Thus, any change in temperature of the water affects the overall aquatic ecology of a river or a lake.

When the power plants exist in a region where water is scare or its acceptance capacity is already saturated, cooling towers are built to dispose off the waste heat into the atmosphere. There are two kinds of cooling towers, the wet one which uses the waste heat for evaporating the water, and the dry one which directly transfers heat into the atmosphere. Dry towers are very expensive to maintain and operate, but have relatively less impact on the environment, except producing noise. Wet towers are huge structures, more than 300 ft in height and hyperbolic in shape. These use natural air draught for cooling down the water which evaporates and falls in small droplets inside the structure. These are responsible for producing fog, cloud and sometimes even affect the local climate. In addition, various chemicals, which are used in wet cooling towers to hinder the growth of organic matter, are also discharged into the atmosphere along with water vapour and pollute the environment.

Benefits

Inspite of the fact that much consideration has been given to the beneficial utilization of the waste heat energy, it has got very limited application, and some of the ideas that have been put forward are as follows: If put on large scale, it can be used effectively for domestic and industrial purposes. Cleaning, heating, cooling and mixing are main areas where it can be effected through. The fish-life can also be regulated through its use.

It can have wide application in agriculture. Warm water irrigation can stimulate growth of crops, extend growing seasons and raise varieties which are not normally possible in the absence of suitable climate. A limited fish-food production can also be done using hot water. It is possible to produce drinking water by desalinizing the steam discharged from a turbine. The water thus produced will be fit for both man and animal. It can be concluded, therefore, that the waste heat has several adverse and a few beneficial effects on our ecological system.

A positive bias to nuclear energy

As we have seen in preceding pages, among all available energy resources, Nuclear and Fossil fuels are the most important ones and the future of the energy supply may possibly depend on these. Non-depletable energy resources are attractive but the most promising of these, Solar energy, is intermittent and unpredicatable in cold countries, and in the absence of relevant technology to produce it on commercial scale, the economic factor will limit its application. Other energy sources, such as Wind power, Tidal power, Geothermal power, etc. are likely to remain limited sources of energy. Further, of all Fossil fuels, Coal is the most important and Oil is also important. Thus, before a preference for any particular energy source can be shown, it is imperative to analyse the most important ones in terms of their economic values and potentialities of hazards to the environment. To do this, I shall begin by presenting some relevant data based on world wide modern surveys and reliable calculations.

Considering the economic factor first, simple calculations can be made to show that, in terms of energy yield, 1 Kg of natural Uranium when used in thermal reactor is roughly equal to 30-35 tons of hard coal equivalent, and this figure rises to 2000 tons of hce if a breeder reactor is used. Also 1 kg of ^{235}U is equivalent to 13500 barrels of oil equivalent (boe), and, therefore, the world stock of 5.6 x 10^4 tons of ^{235}U is equivalent to 0.8 x 10^{12} barrels, or 46 x 10^{20} Joules. This is about one half of the world's supply of crude oil. It is quite obvious from above considerations that the costs of 2000 tons of coal or 13500 barrels of oil can never compete with those of 1 Kg of natural uranium (on an average 40 $/Kg) or ^{235}U, respectively. Further, it may be mentioned that during the burning process of ^{235}U in thermal reactor and some of the ^{238}U is converted into ^{239}U in thermal reactor, some of the ^{238}U is converted into ^{239}Pu, a highly fissile material. This increases the heat content by 50%, and if the Plutonium so produced is recylced in the thermal reactor, the total available heat is further increased by 50%, making it equivalent to 2 x 10^{12} boe or 100 x 10^{20} Joules which is roughly the total heat quantity of the world's crude oil. In addition, if ^{238}U is burnt in fast breeder reactors, the whole of ^{238}U can be converted into ^{239}Pu which undergoes fission very efficiently and enchances the heat content further by a factor of 50. Thus, a total nuclear heat equivalent to 50 times the heat available in world's crude oil reserves can be achieved. However, the cost of mining ores will also go up in same proportion, but estimates show that it will still remain very economical. Further, in a typical reactor which produces 3000 MW of thermal power, consumption of ^{235}U is about 4 Kg per day. To produce the same energy using fossil fuels, millions of times as much weight would be required. It may be pointed out that, in course of time, when Uranium ore becomes too expensive to obtain, Thorium ores can be used to produce ^{233}U, a highly fissile material.

If the Fusion Reactor is developed, there is nothing to compare with it. The energy produced from fusion, in terms of per unit weight, is about 4 times that from the fission of ^{235}U and about 10 million times that from the combustion of gasoline. An estimate based on the deuterium content of sea water shows that each cubic meter of sea water has the energy equivalent of 1360 bbl of oil.

Now turning to the question of hazards, in the case of nuclear energy, it is more psychological than real. It is not exaggerating to say that to a layman, the very term 'Nuclear' means an Atom Bomb, and, therefore, he visualizes only Hiroshima and Nagasaki. But a critical and unbiased analysis gives altogether a different picture. I have already discussed at length various hazards, mainly due to fossil fuels and nuclear fuels, right from their place of origin to the conversion into usable energy form and consumption. Now, I will compare the hazards which result from the growth of nuclear power plants to those from coal or oil-fired power plants.

As regards the danger due to the exposure to radiations from the nuclear power plant, the general population is quite safe. It is significant only for those working in it. The exposure to radiations beyond the prescribed dose is supposed to cause leukemia and to some extent cancer. But, several respiratory diseases and cancer among workers of coal-fired power plants far exceed this limit. Sometimes during 1952 in London, the 'Smog' caused due to fossil fuel combustion was responsible for 3500-4000 deaths. Surveys show that there is a strong correlation between the death rate from 'bronchitis' and airborne sulphur-dioxide levels, which along with other combustion products also cause considerable damage to buildings. The increasing level of carbon-dioxide in the atmosphere have undesirable long-term climatic effects.

Other hazards, which result from the operation of a nuclear power plant, are no doubt significant, but fully monitored at the same time. With existing technologies, every stage of operation of a nuclear power plant, starting from the burning of uranium to the generation of electricity, is within control. For instance, the 'spent' fuel elements are carried in a specially built lead container to the processing plant, where the processing is done by remotely controlled processes in heavily shielded buildings and radioactive fission products are extracted to an extent of about 99.9%. The residue, containing short as well as long-lived radioactive products, is stored in water cooled stainless-steel containers of sufficient thickness to attenuate the radiations and to resist corrosion for at least 100 years. These containers are at present stored at ground level under constant supervision.

Plutonium, produced in breeder reactors, is indeed a toxic material, but not so much as many substances that are used in industry. The danger of it being hi-jacked by terrorists can be minimized by carrying out spent fuel processing at the same site, thereby avoiding the transportation. However, it may be noted that the existing chemcial plants, liquid gas containers and even petrol tankers also run the same risk of hi-jacking.

Now, let us look into some of existing records of health hazards due to coal mining and nuclear industries. In U.K., about 60 miners are killed every year in underground accidents and a high proportion are disabled by pneumoconiosis by the time they reach half of their age. According to the Ford Foundation report on U.S. coal-fired plants, the operation of a 1000-MW station causes two deaths each year. Deaths caused due to respiratory diseases aggravated by gaseous effluent are 18-50 deaths per year per 1000 MW, depending on the location and the sulphur content of the coal. On the other hand, a nuclear power plant of the same capacity (1000MW) causes, as estimated (Hunt, 1980) 0.6-1.0 death per year. The figure includes workers in uranium mining and milling (0.1-0.25), reactor accidents (0.1-0.25), exposure to radiation in reactor opeation and fuel processing (0.2-0.3) and the general public due to increase radiation level (0.2).

It is worth noting that above figures are based on an estimate, but so far there has been no death from accidents in commercial reactors. Thus, the record of the nuclear power plant is really impressive and commendable in respect to hazards.

Conclusion

Energy resources are in plenty and are ready to come to our rescue for an unlimited period of time. Since man holds his future in his own hands, he has to advance his technical know-how to cope with increasing demands of energy. As regards hazards posed by energy resources to our environment, it is difficult to root these out completely, irrespective of energy source, but these can be minimized to a tolerable extent through the use of fission energy and to a negligible extent with the control of fusion - if possible? In the long run, nuclear fusion and direct solar energy conversion (??) can serve the needs of mankind for an indefinite period.

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15.3

ON THE ADULT EDUCATION IN PLANNING THE RENEWABLE ENERGY STRATEGIES FOR RURAL SELF SUPPORT

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Abstract

In recent years, considerable attention has been paid to the utilization of renewable forms of energy for future needs of mankind. The efforts have, however, been directed mainly towards solving the problems of population living in urban areas; the rural sector energy needs have not been paid sufficient attention. The population living in these isolated communities should now be made to come forward to participate in the overall development of their respective nations by demanding an appropriate share in the energy consumption patterns without affecting the already affluent sectors. In fact, the developing nations should involve their rural population in solving the energy problems. This could be accomplished by educating the rural adults in planning their strategies for proper and efficient utilization of locally available renewable energy resources. The people, the resources, the requirements and the energy applications need to be coordinated in order the energy sources become useful and the energy technologies may add to the socio-economic vector for rural self support. A commitment to include energy education as an essential element in the National Adult Education Program is stressed, and methods, materials and aids for energy education for rural adults have been suggested in this paper. The various curriculum components, actual plan of action and its implementation have been discussed.

Introduction

The energy crisis, being experienced the world over, has hit hardest at those who have the least energy available to them, i.e. the rural population in developing countries comprising the majority of world population. They live in isolated communities having agriculture as the principal occupation. Their energy requirements are two fold: (i) energy for survival of their own, and (ii) energy for agriculture production.

For survival of their own, rural people have minimum requirements. The traditional energy source for them has been firewood, although commercial fossil fuel sources (coal, gas, petrolium etc.) and to some extent electricity are also available for them. Excepting electricity (through transmission lines from a centralized power plant) and firewood, the other fuels have to be transported to the rural sector often from far distant places in the respective nations. The transportation infrastructure being very poor for rural areas, considerable amount of commercial fuel, supplies of which are consistently dwindling, has to be consumed on its transportation. This operation adds to the consumer price. The major part of the rural population has, therefore, to depend on firewood which is more economic to them. This tendency has put the forests under severe threats due to indiscriminatory cutting of trees. Firewood, in turn, is becoming scarce. The energy crisis for the rural populations, thus, means having to walk further and search harder for firewood. This makes firewood collection more human labour and time consuming.

With the continuous drift of population from rural areas to the towns and cities in search of jobs, a proportionately smaller number of the population is left for agriculture production to feed the rapidly growing population. The farmers have to intensify agriculture production by working for more time on more of the agriculture land with more agriculture inputs. The appropriate agriculture inputs like fertilizers, irrigation and other pre- and post harvesting operations, pesticides, high yielding variety seeds are all intensive energy consuming. More intensive cultivation techniques for more production means higher and higher energy inputs. On the other hand the consumer cost of the conventional energy sources is so high in comparison to the agriculture products, the rural sector feels reluctant to use energy inputs liberally. Unless the energy provided to the rural sector is almost free, the agriculture production can not be economic. This is the main reason for the poverty of the rural sector and the situation does not seem to change till the rural sector energy needs are met on economic considerations.

Considerable efforts are, therefore, being made by many nations to utilize their renewable energy resources to meet, wholly or partially, the energy needs of their populations. Unfortunately, these efforts have traditionally been directed to solve the urban sector problems neglecting the rural sector. However, the rural sector has ample resources of renewable energy as well as material resources to develop the hardware and systems necessary to tap these energy sources. The primary need is to train the rural adults in the comprehension of the technologies and in source and material handling.

Methods, materials and aids

A universal solution for renewable energy utilization for rural needs cannot be suggested and to search for such a solution would be highly erroneous. A single renewable energy source may not be sufficient for the needs of a given geographical location. Inevitably, a relationship between various energy sources will have to be established and a relationship between various appropriate energy mixtures for an appropriate application will have to be determined. Any energy education programme for rural adults will, therefore, have the geographical location of the region, potential of the renewable energies in that region, the energy requirements of the population living there, the socio-economic and cultural aspects of renewable energy applications for the population of that region as the principal elements in its design. It is essential to classify the available renewable energy sources according to the following scheme:

(i) sources that are plentiful in supply and possess regional application possibilities (Genotypes),

(ii) sources that are easily renewable and have the possibility of immediate application at a district or block level using available appropriate technology (Phenotypes),

(iii) sources that are easily renewable but appropriate technology for their application still needs research and development work,

(iv) sources that are limited in supply but easy to renew and can be used in auxiliary systems in conjunction with the conventional energy applications,

(v) sources that are presently dirty but have possibility of being cleaned to protect environmental quality. The cost of cleaning should also be assessed.

Once we know the energy scene from the above classification, a check list can be prepared for utilization options in a given area depending on the energy availability and the requirements for various applications. Typical examples of appropriate use of renewable energies on a regional basis are given below 2-3. The list includes both the natural renewables as well as manmade renewables.

(i) Alaska, Finland - Precipitation (snow). as insulation

(ii) Caribbean Islands - Wind for power and cooling

(iii) Holland - Wind and tidal energy

(iv) Hot dry deserts - Evaporate water cooling

(v) Iceland and Hawaii - Geothermal

(vi) India - Gobar gas (methane) from human and animal manure

(vii) Malawi - Energy crops

(viii) South-East Canada - Hydraulic

There can be numerous educational methods for rural adults, the successful would be the one which could create in the rural sector a sense of confidence and independence in their energy needs. In order that this could be done, the educational programme should contain in it the assurance in the rural adult in respect of the following:

(i) the use of renewable energies can raise the standards of living and more specifically, the productivity of rural areas. This in turn would reduce the attraction for the rural population to continuously move to urban areas for better living and maintenance.

(ii) Many renewable energy technologies are labour intensive both in their construction and operation. Thus through adult energy education, there is an opportunity in learning new skills, and for the meaningful employment of many of the rural adults in using their labour and local materials.

(iii) The rural sector can create capital and reduce spending on fuel (save time for firewood collection etc.) or spare parts for conventional energy systems which otherwise come from outside the community or even imported. This will allow greater cash flow within the community and strengthen these areas economically.

(iv) The renewable energy application will allow local manufacturing facilities for the construction of renewable energy equipment and will thus positively affect the economy of the country as a whole.

(v) the Rural population will have more control over their production system which in turn would reduce wastage and increase output.

Plan of action

In order to convince the rural population of the benefits of having renewable energy based systems, one has to plan strategies such that the appropriate technologies fit into appropriate systems. All elements of the strategy planning, namely, the technologies, resources, system designs and the rural adults who are supposed to maintain, administer, operate and use these renewable energy technologies, must interact in harmony. As already indicated above, the technology must be within the reach of the rural sector. It should be appropriate, technically and economically sound, culturally and socially acceptable and must respond to a real need of the rural sector. It may be mentioned here that even the best technology fails if no one can operate, maintain or use it.

Education for rural self support in energy:

Hence, in order that the available renewable energy technologies become successful in the overall rural sector development, the participation of rural adults in the entire process i.e. from development of appropriate technology to its actual use for the real needs of the community, is not only crucial but also essential. The renewable energy bridge for the rural sector development can be made only be keeping the rural adults as the base. In other words the rural adults are the key to the rural development for energy self support. Thus it is essential that the developing nations, for the development of their respective populations living in rural areas, should commit to:

(i) include the energy education as an essential element in the National Adult Education Programme,

(ii) the investigation and application of renewable energies (both natural and man made) to the development of rural sector.

(iii) an area wise assessment and evaluation of energy requirements of rural population (past, present and future). Simultaneously the renewable energy availability should also be assessed.

(iv) make a comprehensive classification of the rural sector energy requirements for various applications (cooking, heating, cooling, food preservation, food processing, lightening, water pumping, etc.),

(v) design application wise combination of one, two or even more renewable energy types depending on their availability in a given area (mixture of solar, hydraulic, wind, biomass, bigas etc.)

(vi) manage harmoneous interaction between commercial sector companies active in renewable energy applications, research, development and education experts, extension workers, social organizations and other government and semi-government bodies responsible for national energy programmes.

(vii) provide a facility for the coordination of all renewable energy systems in a given areas of well defined boundaries.

(viii) arrange installation of demonstration projects in a given area and provide all the infrastructure facilities including repair and maintenance depots to be managed by the rural adults.

(ix) provide low interest loans to rural sector for installing infrastructure facilities pertaining to development of renewable energy systems, for their repair and maintenance etc.

(x) institute training programmes for rural adults in regard to renewable energy applications, their use for various needs, their operation, repair and maintenance.

Education for energy conservation:

Apart from looking for the renewable energy sources for rural self support, steps should also be made to optimize the performance of the already available energy systems. Many heating or cooling devices are used by the rural population using local materials. Their use is highly inefficient and wastage of energy is through the operational and design defects. The properties of the building fabrics should also be optimized to save energy including the architectural aspects of low cost houses. The adult energy education programme can make rural adults aware of the energy wastages in their houses as well as in cultivation techniques like irrigation where the water transporting pipes or channels have high leakage problems. The adult education programme can train them to choose the local materials for energy conservation without affecting the agriculture production. The testing of soils for selecting the crop is again an essential element in rural sector energy saving strategies.

Education for environmental protection:

Unlike the agriculture economies of 200 years ago which could survive on natural solar energy, the advanced cultivation techniques of today need not only devices using solar energy in its natural state but also apparatus to change it into artificial forms like electricity by photovoltaic conversion, heat by photothermal conversion, chemical energy by photochemical conversion and even mechanical energy by indirect photo conversion. These conversions should be capable of powering modern machines and there should be means to store this energy so as to ensure a continuous supply even when there is no sun. Although the direct conversion of solar energy into electricity offers the prospects of an unlimited and non-polluting supply, the solar energy device costs for photovoltaic conversion are too high to be within the reach of the poor rural sector. The other renewable energy conversions like the biomass and biogas can be hazardous to environment if proper care is not taken at the device design stage. The rural adults, therefore, have to be not only made aware of the environmental problems but also be convinced of the consequences of environmental protection on the over all economy of the sector.

Conclusions:
The implications of introducing adult energy education programme to rural aduts are significant. Through this programme they can be trained to design their own strategies for independence in energy using renewable energy sources and local materials. What is needed is a careful planning by interdisciplinary teams. However, before introducing such programmes, the legal, social, financial and technical aspects of renewable energy utilization should be fully understood and their economic gains (both on a short term and long term basis) calculated.

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15.4

ENERGY IN PHYSICS CURRICULUM: A PROPOSAL AND A PLEA

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Abstract
The paper discusses on the importance of energy in the physics curriculum and the relevance to the Malaysian scene. On the basis of information available from universities and research institution in Malaysia, the current state of energy education and research is reviewed. A modified physics curriculum in energy study is presented. The importance on interaction between public and university is highlighted.

Introduction
The so-called modern society has been characterised by the replacement of machines for human and animal power. In agricultural societies for example, the ox-plough cropping, traditional hand-operated plantation and bicycle for transport have been replaced by modern diesel tractor and motorcycle. Machines have dominated the thinking and way of life of the modern society.

The industrial period has brought about two important changes in the pattern of consumption of a) natural resources and b) energy. Not only that, it has also created an unfavourable environment, i.e. pollution.

Now energy has become the world's most important commodity for industrialised nations. It has become clear as never before, the economies of the world depend on secured supplies of energy. This paper attempts to review an energy scenario and energy education in Malaysia. A modified physics curriculum which includes topics on energy is discussed and the importance of interaction between public and physicists (or scientists) in relation to energy study is further explored.

Energy scenario for Malaysia
The pattern of energy consumption in Malaysia is shown in Table 1[1]. It can be seen that electricity, private consumers, industry, mining and transport consumed quite a large proportion of the total energy. Electricity in particular is heavily dependent on oil (approximately 85%). It is expected that by 1995, the electricity produced by oil-fired stations will be reduced to about 45% of the total electricity generation. Other sources like hydro and thermal gas-fired will be utilised (see Table 2).

Turning now to the demand projection for energy based on the existing data. Wong[2] has estimated a demand projection using a compound curve for Malaysia, that is

$$D_n = D_o(1 + r)$$

where

D_n = Demand in year n
D_o = Demand in year o
r = rate of increase of consumption

r has been taken as 0.073 using data from reference 9. It is clear that the demand of energy will be greater as the country goes to industrialisation The energy technology will play an important role in Malaysia's future social and economic development. This is the area where both trained manpower and expertise is required and the role of energy education is extremely important. We shall review these two areas in the next section.

University undergraduate courses
A survey from the information available through universities calendar and personal communication reveals that;

i) The physics curriculum in the five universities in Malaysia is based on the following topics
   a) mechanics
   b) thermodynamics
   c) sound
   d) optics
   e) electricity and magnetism
   f) electromagnetic theory.

   Those courses are well known as classical physics developed before nineteen century ago. During the latter stages of training i.e. in the third and fourth year, courses like quantum mechanics, relativity, solid states, nuclear physics and electronics are taught as compulsory or elective subjects.

ii) The courses developed very independently lack coherence and structural unity. Jafri[3] has reviewed the current physics courses in South East Asian universities and wrote

> "the courses are remarkably rigid and stereotyped and are heavily biased towards the transmission of a large volume of information. Physics is presented as a closed dogmatic system of immutable laws which can only be studied in the language of mathematics. This dampens the enthusiasm of many students and alienated them from the subject."

iii) Only universiti Sains Malaysia and universiti Kebangsaan offer energy courses in physics curriclum.

iv) None of the physics departments include topics on pollution, environment and conservation in their curriclum.

Postgraduate study and research
Facilities for postgraduate study leading to the award of M.Sc and Ph.D. degree are available in all five universities. Table 3 shows the higher degree graduate output from 1970-1978. The degree can be taken through course work and project report. From Table 3, it can be seen that there are few students enrolled in M.Sc or Ph.D. programmes. The reasons seem to be,
   a) Government and private sponsors mostly send postgraduates overseas.
   b) With the exception of universities and research institutions, job opportunities for degree holders is not encouraging.
   c) Research activity does not really 'take off' in our universities.

Unlike the univesity in industrialised countries, university's research in Malaysia has very few external support and collaboration. K.J. Ratnam wrote

> "Although there has been increasing industrialisation in the country, the multinational and other foreign companies that have participated in this development have not seen fit to spend any part of their R and D budgets locally. Thus although many of the new industries in the country spend significant amounts from their corporate funds on research, they do so only through research networks which by and large are confined to the industrialised countries of the West and Japan."

We shall now look at the energy programme and research in Malaysian universities and research institutions. Table 4 shows research activities in energy[5]. One could conclude that energy study is not neglected in all universities. Perhaps an interesting point to note is that the physics department at University Teknologi does not play a significant role in energy activities. Undoubtedly, by tradition, energy study is dominated by engineering faculty. The major problem in our opinion, is lack of collaboration in research interest. Research is an expensive enterprise. Hence, local expertise and facilities should be fully utilised. Perhaps a national committee should be created to coordinate energy research activities in all areas. (I understand that such a committee already exists in the Ministry of Science and Technology)

Energy curriculum?
Having studied the 'state of the curricular art' of physics curriculum in the country, the question now arises as to whether we are prepared to introduce a multidisplinary course like energy in our curriculum. The present curriculum failed to accomodate energy, the 'important commodity' as mentioned earlier.

Traditionally, in physics, the approach in energy begins with topics like thermodynamics and mechanics. It then spreads out to conservation laws and other forms of energy. Clearly the topics in heat and force are developed independently. This may be the best way to start with. Their relationship is then discussed in mechanical equivalent of heat. This approach may not be appropriate for students with poor physics background. What are the alternatives for the development an energy curriculum or physics curriculum in general? Our present curriculum is a heritage from the British system. Although we gained an independence almost twenty years ago, the education and examination procedures have not really been changed. In this respect, Jerome S. Bruner[6] has expressed disagreement about the idea of imitating an educational system of one country another. He said

> "Let me first argue that if you try to imitate the pattern of educational practice as now exists in schools in technologically advanced societies you will be chasing after a chimera because there is no question that our present educational system in 'advanced' countries is wildly in transition."

Historically, the educational system in western society is a heritage from the industrial revolution. Bruner goes on to say that the dynamism for educational reform does come from outside the system.

The education in a developing country should be concerned with problems that exist within the country. The education must suit the cultural conditions and practices of the society. In short, it shsould be integrated in to the activity of living so that science will be in harmony with the cultural values hence contributing to a better quality of life.

Let us see whether we could implement some of the basic philisophies mentioned above in the context of energy study. The populations of Malaysia is approximately 13 million with about 70% living in rural areas. The economic activity in this sector is mainly agriculture and processing agricultural products which contributed 45.5% of the foreign exchange earnings and employed about 1.9 million workers or 49.3% of the total work force in 1975. The economic activities in rural areas which require energy is shown in Table 5. In food drying and processing,. The main crops ar rice, coconut, rubber groundnut, tapioca chips, coffee and cocoa. The industrial drying includes tea, textile, ceramics, sugar, paper, dyes, resins, starch and timber.

Interaction of physics and society

The subject of physics (or science in general) with society has been discussed during a conference on physics education at the University of Edinburg[7]. The conference recommended that

i) Teaching journals should include articles on 'science and society' topics

ii) Physics organization should provide an opportunity for discussion of science and society.

iii) Communication between scientists working in science and society and its problems should be encouraged.

For a developing country, I believe the involvement of science and society is of great importance. This is in view of the fact that,

a) The number of school drop-outs in urban and rural areas is rather high. In Malaysia for example, during 1975, the percentage of drop-outs in 'O' level examination was 38%[8]. These students have not been able to be exposed to higher education. The involvement of scientists outside the university circle will stimulate the participation of the vast majority of disadvantage group in scientific activities.

b) Education should not be limited to school systems. Again here the responsibility of training should be shared by industry, business and all relevant authorities out-of-school system.

Energy offers physicists the chance to participate in a public debate which is highly important for science and society interactions. Energy education does not only confine to within the four walls in a class room. In any case, in energy studies, the emphasis should be given to the co-curricular and non-formal components of education. Direct linking between public organization and the university should be encouraged. Activities like exhibition, public lectures, forums and seminars on contemporary issues in science and society must be highlighted.

Conclusion

The existing physics curriculum can be modified to include topics on energy and problems that are more relevant to the community. Energy education has offered an opportunity for physicists to participate in science and society activities.

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Table 1. Pattern of energy consumption by sectors (%)

	1970	1971	1972	1973	1974	1975
Agriculture	9.1	9.2	8.3	8.5	10.2	8.2
Mining	14.0	13.0	13.0	11.2	9.0	10.3
manufacturing	12.2	11.1	11.1	10.2	12.2	11.0
Construction	1.5	1.7	1.8	2.2	1.7	2.1
Electricity	17.7	20.0	20.7	22.0	23.4	24.3
Transport	10.0	8.8		10.5	9.8	9.7
Wholesale/ Retail	7.5	7.2	6.2	6.8	5.2	5.3
Dwellings	0.9	0.9	0.9	1.1	1.0	1.0
Public Administration	4.3	5.5	5.3	3.8	3.2	3.7
Other Services	0.5	0.5	0.4	0.4	0.4	0.5
Private Consumers	22.4	21.9	23.4	23.2	23.6	23.8

Table 2. Generation of electricity. Annual generation and percentages by plant categories

	Hydro %	Thermal Oil-Fired %	Thermal Gas-Fired %	Total (10^6kwh)
980	15.6	84.4	-	8716
1985	23.1	64.1	12.8	9413
1990	15.7	61.9	22.4	26740
1995	11.6	44.1	44.3	42860

Table 3. Higher degree graduate output, 1973 - 1978

Universiti Sains Malaysia	62
Universiti Kebangsaan Malaysia	3

Table 4. Energy research activities in university and research institution in Malaysia.

University/research institution	Area of interest	Staff
UKM (Phys. Dept.)	solar refrigeration solar cooking	10
SIRIM	solar dryer photovoltaic, bioconversion	3
UPM (Dept. of Environ. Sc.)	flat plate collector solar cooling	16
UPM (Faculty of agricultural engineering)	crop drying, wind energy water heating	2
UPM (Dept. of food Sc. and technology)	solar drying solar distillation	22
UM (Dept. of mechanical engineering)	Water heating, crop and timber drying	18
USM (Phys. dept.)	Photovoltaic solar radiation, water heating, drying, cooling	28
UTM (Engineering)	refrigeration	

UKM	= Universiti Kebangsaan Malaysia
SIRIM	= Standard and Industrial Institute of Malaysia
UPM	= University Pertanian Malaysia
UM	= University Malaya
UTM	= Universiti Teknologi Malaysia

Table 5. Rural tasks requiring energy

cooking	lightning
telecomunication	desalination
distillation	pasteurization
sterilization	refrigeration
cooling	transport
water pumping	plowing
planting	fertilizing
weeding	grinding
harvesting	food drying and processing
wood cutting	spinning
sewing	industrial drying
small industry power	materials processing

15.5

ENERGY EDUCATION A TRAINING PROGRAM FOR DEVELOPING COUNTRIES

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Introduction

The dramatic forecast of the coming energy crisis has stimulated the search for new and renewable energy sources. In view of the fact that the exciting sources are limited and at the same time their exploration is growing steady, the need to find new energy sources having the potential to compete effectively with conventional resources is all the more obvious.

National energy surveys, analysis and assessments of user needs, of resources and of conversion technologies have been conducted or are under way in most countries. However, few countries have been able to find the skilled personel in these fields. The experience in alternative energy sources is quite recent: infrastructures meeting trained manpower requirements are usually non-existent or inadequate. One cannot but be compelled then to fall in with the real need for a specialized education and training program. The curricular contents must give heed to the introduction and utilization of new and renewable energy sources.

The four principal areas should be included in the curriculum addendum: assessment of resources, knowledge of conversion technologies, planning and management of those technologies and economy of energy utilization. The basic training seems to be universal for every country. On the other hand, each region owing to its geography, relies upon its own economic possibilities, its cultural background and its often adament problems. It therefore stands to reason that the curricular contents should be twofold: they must be designed to suit the specific situation in each country with respect to diffe rent types and numbers of skilled personnel required as well as to the importance of blending educational and industrial elements. Such considerations explain why the four areas of education programs do not carry the same weight for different countries. Quite different approaches will be undertaken when setting up training programs in an industrialized country as compared to a developing or rural type one, for instance. In a country with limited economic possibilities, the central dilemma boils down to making a pondered choice of the optimal mixing of both new and renewable energy all of which are suited to their resource endownement, the conversion technologies available either immediately or on a short term to exploit these resources.

In order to better illustrate some specific problems linked with developing countries, we will give you some data about Senegal, a West African country. The data gathered and related problems are very similar for most other countries situated in that region of Africa and referred to as Sahalian Africa. Similarities with countries included within the Sahalian Belt are with regard to geography, noticeable weather conditions, demography and the professional profile of the population.

Text

A first interesting point - a salient feature of the area - concerns the proportion of the population involved in urban industrial/commercial activities and rural ones. Senegal, with an area of 196,722 Sq.KM, numbers 5,114,000 inhabitants .30% of the population lives in urban areas which in turn fill 1.43% of the whole territory. We can refer to this population as "industrial" and "commercial" since 8% of the country's industries are concentrated in urban areas .70% of population is referred to as rural and is spread irregulary over the rest of the territory.

It is necessary to emphasize that the city of Dakar, like any modern city with its sophisticated facilities, matches any large American city with regard to energetic problems. Most industrial equipment is automated and managed by well trained Senegalese personnel. For this small part of Segelese territory, totalling 1.43% of the total area (other cities included), the education program on Energy will be very similar to that applicable to any industrialized country. It is very important and interesting but we have to bear in mind the proportion of the population. For this reason we must endeavor to look into rural area needs for it is impossible to seek economic progress for any given country, especially in Africa, without involving rural development.

Such a problem becomes of utmost significance in a country like Senegal when the economy depends on rural production. Statistics gathered by S.I.N.A.E.S. (Society for Solar Energy Application) indicate that 56% of the population is wholly rural and 14% semi-urban. The latter figures should be comprised within the rural group. Amid this rural population stratum, 46% of whom are farmers: 6% breeders and 40% cultivators and 44% without any precision but living in rural areas. Fishermen make up 10% of the whole population and their energetic problems can be assumed either traction power for their fishing boats or in improving the fish drying process. Up to now the remaining rural population is largely dependent on the changeableness of the weather. In that region the dry sesson lasts between 8 to 9 months. (October to June) and the rainy season, theoritically at least extends 3 or 4 months. The pastoral and farming conditions are difficult, but they become ever more so when the rainy season is shortened or delayed. It is clear that the lack of energy stands as a major obstacle to progress owing to restrictions imposed by the weather conditions.

Here lies the paramount difference in matters of energy problems between industrialized countries and rural ones. The latter are in great need of energy itself to exist and to become self-sufficient. The developed parts of the world are striving to substitute existing energy forms by new ones in forecasting the difficulties. Therefore in developing countries such difficulties exist on a day to day basis. Education and training programs should take such differences into account. Before evaluating the weight of some curricular contents let us look into some of the principle needs which are typical for an African village and identified by "La Comission Consultative de la Recherche au Senegal" (The Consulting Comission on Research in Senegal). These are:

a. Water supplies, personnal and pastoral users: 201 daily per inhabitant, 40 1 daily per cow and 6 1 daily per sheep:

b. Wood production for use as direct fuel. It is interesting to know that wood as an energy source covers a 63% of national energy needs;

c. Treatment and conservation of food products (refrigeration, drying)

d. Energy supply for dispensery, maternity wards and veterinary facilities;

e. Motive force (pumping, grinding), electricity (light, telecommunication).

A careful analysis of this listing of needs leads to the conclusion that the solution is perhaps simple. Electricity will immediately resolve all listed problems. Conventional production of electricity is still based on petrol and hydro projects remain only as projects. We can now start by the first area of the training program: assessment of sources.

The most evident and logical energy source should be the sun: consequently the main subject of the training program would be solar energy. The climate data for the Dakar region indicates that there are 3000 hr/year of sunlight exposure in this area. The global solar radiation varies between 4.7 kWh/m2 day and 7.02 kWh/m2 day. The transparancy of air is good. So this region is certainly suitable for exploitation since it gathers ideal weather conditions. We have two kind of solar generating systems: thermodynamic and photovoltaic, but both up to now are very expensive.

Nevertheless, the first solar pump was designed and set up at Universite de Dakar but only four units have been installed since 1976. Despite the price of thermodynamic pumping systems, is another problem is the highly qualified personnel requirement. The simplest and most useful are the water heating systems which seconded by an appropriate training program may be constructed on a craft-like scale. The wind power systems are efficient up to 50 km from the seashore and very frequent sand storms seriously destroy the wind-mill mechanisms.

These "classical" renewable sources are limited in exploitation so why not resort to the long time forgotten energy of animal muscles? The Director of the Indian Institute of Management, Bangloie, Mr. N.S. Ramaswamy wrote in the Occasional Paper No. 10: "The development of animal energy sources, their proper utilization and more timely care of the work animals would assuredly benefit millions of poor people, farmers and carters, the environment, the economy and society at large." It is proved however that each animal of the bovine family is capable of generating half a h.p. We now see a new and unusual subject in the curriculum.

Let us turn to the "wood problem" so characteristic of the Sahelian region. Wood is the principal source of primary energy and its consumption largely exceeds its regeneration possibilities. The future of the population of this region is heavily dependent upon the solution of this particular problem. Once more including this subject in an education program seems irrelevant for the industrialized countries.

Some examples given in the paper clearly show the need for training programs that are region oriented. We have to add to those specific problems different traditional cultural customs which should be involved in the curriculum so as to ensure adequate and efficient training and to further improve the development of rural areas.

In conclusion the energy education and training program for developing countries should endeavor to grasp the true problem of the region, the comprehensive involvement of the population.

Well aware of the importance of energetic needs for Senegal the École Polytechnique de Thies has introduced this year a new course focused on Energy Conservation and Exploitation. The course will be given to all 3rd year Engineering students and will consist of 45 hours, that is, 3 credits. Course description:

Primary sources of conventional energies: petrol, natural gas, coal, hydro electricity. Their conversion and use in industry, transportation, agriculture and housing. Perspectives and conservation. Nuclear energy (nuclear fission) as generator of electrical power. Exploitation of unconventional primary sources as geothermic, tidal.

Renewable energy sources: the sun, biomasse, wind, wood, muscles.

Solar energy: urban, industrial and rural applications.

Generation of electricity: photovoltaic panels, thermodynamic systems, eolian conversion.

Bioenergy: conversion into liquid, gazoeus and solid fuels. Resulting impact on environment.

Muscular (animal) energy: water pumping, irrigation, generation of electric power.

Solar chemistry, fuel cells, M.H.D. etc.

The data for the paper have been gathered from: Solar Energy and Distribution of Electricity - conference organized by African Union of Producers, Transporters and Distributors of Electricity (U.P.D.E.A.) in Dakar,6th to 9th of January 1981, Documents of the Secretariat of Research and Technic in Senegal, Documents of Industrial Society of Solar Energy Application (S.I.N.A.E.S.)

15.6

DEVELOPMENT OF THE FIRST ENERGY COURSE IN NIGERIA.

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Abstract:
Nigeria is one of the OPEC countries and is regarded as the most fast developing nations in black Africa. This trend in development is leading to various forms of energy problems. The country is presently engaged in the establishment of an Energy Commission which will lead the way towards the establishment of energy research centres.

The need to provide experienced energy experts in the country should not be overlooked. The author of this paper, who has been involved in energy research for several years, has concluded negotiations with the Institute of Energy of the United Kingdom to run the Institute's Diploma course in Energy Management: This energy course which will be on a part-time basis will commence in September of 1981.

This paper will discuss the problems involved during the development stages for this energy course. Details of the training programme and the expected influence of these courses on national development will be discussed in this paper.

15.7

ENERGY SITUATION IN INDIA — EDUCATING THE PUBLIC

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Abstract
India's import bill of crude and pretroleum products in 1980 was nearly Rs. 5,000 crores while its earnings from exports hardly exceeded Rs. 7,000 crores. It is feared that by 1985-86 these figures might reach Rs. 16,800 and Rs. 11,300 crores respectively. Thus there is a very big question mark about the foreign exchange required to pay for oil imports. The total energy demand in the country by 2000 A.D. has been estimated at 1,150 mtce. Commercial energy of 92 million tonnes of oil, about 530 million tonnes of coal and 1.29 MW of electricity would be the inputs required and this target is difficult to achieve. It is imperative that non-commercial sources of energy have to be developed in the country to meet energy requirements particularly in the rural areas where 80% of the population live. Efforts are on to utilise solar, biogas and wind energies. Pilot projects in every district in the country are proposed using these sources. The sixth plan has allocated as much as 27% of a total outlay of Rs. 97,500 crores for the energy sector.

Perhaps certain harsh decisions have to be made to conserve energy, particularly oil. Educating the public through the media like radio and T.V. is one of the measures to impress on the public the need to utilise alternative energy sources and at the same time not to waste commercial sources. Many institutions are involved in designing gadgets to utilise the non-commercial sources of energy, but very few Universities have undertaken any schemes. There is also need to include in the school curriculum, particularly at High School level, and in the graduate and postgraduate courses of study the subject of energy resources, conservation and management. Seminars would help, but these would touch the top elite only. Science Centres for Villages would be useful proposal to reach the villagers the message of energy crisis.

SESSION 16: BIOLOGY RELATED PROGRAMS

16.1

THE EMERGING FOOD/FUEL TRADE-OFF

by
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Abstract:
The sharp increases in energy prices observed since 1973 has complicated the task of feeding the world's expanding population. Each country, with its unique mix of agricultural resource, technology, food and energy needs, and production potential, is searching to find the best adaptation both to current energy costs and to anticipated future oil price increases. As in other sectors of the economy, this adaptation process is only beginning. Modern commercial agriculture is particularly vulnerable to oil price increases because of its need for scarce petroleum and natural gas based fuels. Furthermore, agriculture is strategically important in some countries because it is being called upon to provide fuel in the form of alcohol or direct combustion energy feedstocks. These uses compete directly with food for the use of agricultural land and other inputs. Thus, the emerging food-fuel trade-off is a double edged sword that on the one side increases the costs of food production and other takes part of the production for non-food (fuel) uses.

Only now is significant amount of attention starting to be focused on the ways in which agriculture is accommodating itself to the radically changed economic environment existing in the 1980's. By surveying recent developments in American agriculture, this paper's two-part discussion characterizes agricultural adjustment to current high energy prices. First, the relationship between food and energy is explored along with some of the impacts of various methods used to diminish both agriculture's and society's reliance on fossil fuels. This discussion of energy dependency lays the groundwork for an analysis of market and policy response to the food-fuel trade-off. That analysis is contained in the final section of this paper.

The Food/Energy Relationship

Compared to the broad sweep of human history, the length of time during which industry and agriculture have depended on fossil fuels is very short. Traditionally, renewable resoruces, especially biomass (e.g., crops, wood, charcoal, etc.), have provided the bulk of energy needed by society. Even as late as 1915, approximately 25 percent of U.S. crop production was used to feed mules and horses, which powered a great deal of this country's farming activity and transportation[1].

During the past one hundred years, American agriculture, like agriculture in many other countries, has greatly reduced its dependence on renewable power sources. Instead of harnessing animal or human power to plow fields, thrash grain, and perform other tasks, the U.S. farming sector has chosen to rely on fossil fuel resources.

It would be hard to understate the extent of U.S. agriculture's transition from "living" to fossil energy sources. Gasoline and diesel fuel power the nation's farm machinery. Large amounts of petroleum are expended in the production of chemical fertilizers, insecticides, and herbicides. In addition, much of the United States' extensive irrigation system is operated on natural gas. Because of these and other uses, American agriculture is more dependent on fossil fuels than is the rest of the economy: oil and natural gas account for 85 percent of agriculture's energy budget whereas those two fuels account for only 75 percent of the entire economy's energy budget[7].

In terms of the effect on food production, substitution toward fossil fuels has been a success. The growth in per acre crop yields observed in this country since the end of World War II coincided with widespread implementation of energy-intensive farming techniques. For example, it has been argued that one half of the United States' remarkably high corn production can be attributed to direct energy inputs[8].

Clearly though, the commitment to an energy-intensive agriculture implies a trade-off between food production on the one hand, and depletion of nonrenewable fossil-fuel resources on the other. While oil and natural gas prices were abundant relative to our consumption levels, energy prices remained low and the costs of this food-fossil fuel trade-off therefore remained acceptable. However, as petroleum has become more scarce, thereby allowing the prices of all forms of energy to climb, the energy input cost associated with food production has become more dear.

There are a number of ways to deal with the food-fossil fuel trade-off. In the remainder of this section, three basic types of proposed solutions—decreasing food demand, switching from energy inputs to other kinds of inputs, and developing alternative energy sources—are examined. As will be shown, there are constraints on the viability of each option. Furthermore, adoption of many measures intended to ameliorate the food-fossil fuel trade-off will create other types of troubling trade-offs.

The first solution to the food-fossil fuel trade-off is to decrease demand for food, either by limiting population growth or by altering individuals' diets. Lester Brown of the World Watch Institute has compiled some figures that indicate the potential is great for reducing food demand by using the latter approach. He estimates that an "affluent" diet, since it includes a large amount of beef, requires roughly four times the grain needed for a "subsistence" diet[3]. One might speculate, for instance, that a switch in consumption from meat to poultry, which is a more efficient converter of grain to protein, would reduce demand for feed grains. This would in turn reduce energy demand. However, such an observation begs the question of what changes in price signals are required to induce the large consumption switches needed to effect an appreciable reduction in agriculture's energy demand.

A second way to address the food-fossil fuel trade-off is for agriculture to subsitute non-energy inputs for energy. This option is limited, though, because increased employment of non-energy inputs frequently creates other types of serious trade-offs. For example, increasingly intense use of agricultural land has caused serious erosion, salination, and other environmental problems in this country[9], just as it has in other parts of the world[1].

A third method to contain the costs associated with high oil prices is to develop alternative energy sources. One frequently recommended alternative is coal. Because this country possesses abundant reserves of that mineral, a switch to coal would presumably decrease the costs of the food-fossil fuel trade-off. However, the cost of obtaining a barrel of liquid fuel from coal is currently estimated to exceed $50[8]. Since agriculture is particularly dependent on liquid fuels, a switch from oil to synfuels would therefore not be cost effective.

Another alternative energy source is liquid alcohol fuels made from biomass. In this country, corn would be the principal input for alcohol production. However, implemenation of this alternative would reintroduce trade-offs which agriculture has avoided during its period of dependence on fossil fuels. Instead of using all available crop production to feed humans and livestock, a sizable portion of corn output would have to be diverted to the manufacture of liquid energy inputs. Besides this trade-off between food and animal feed, on the one hand, and fuel, on the other, biomass development would generate environmental trade-offs. Dr. Samuel Flaim of the Solar Energy Research Institute points out that, by collecting crop residues for alcohol production instead of leaving them as a protective covering on the ground, this country's already serious soil erosion problems will be significantly exacerbated[6].

The food-feed-fuel trade-off implied by biomass energy development is made even more serious by the prospect that alcohol fuels will be consumed in all sectors of the economy. Purdue University agricultural economist Otto Doering estimates that a complete national switch to gasohol (a 10 percent alcohol/90 percent gasoline mixture) would require 60 percent of the nation's present corn crop[4]. The food and feed versus fuel trade-off generated by this massive demand growth could be lessened somewhat by feeding the distillers' grains, which are a by-product of alcohol production, to beef and diary cattle. This would in turn reduce demand for soybeans and therefore free up some additional land for corn production. However, this approach to easing the food-feed-fuel trade-off may be limited in part by the degree that cattle populations can be concentrated near alcohol plants. This is because drying of distillers' grains for storage and use outside of a paticular locality involves additional energy costs.

Market Response and Public Policy

The preceding section provides an overview of the kinds of trade-offs implied both by the dependence on fossil fuel resources as well as by means to ease that dependence. This section discusses how market forces can be expected to deal with those trade-offs. In addition, the remainder of this paper will analyze some of the arguments put forward for policies intended either to inhibit or to reinforce those market forces.

Whenever an input becomes scarce, two trends will be observed. First, producers will attempt to substitute away from that input. Second, the prices of goods which require relatively large amounts of the scarce and expensive input will rise, thereby decreasing consumption of those goods.

The fossil fuel energy crunch has engendered both responses. Agriculture is seeking ways to economize on the use of oil and natural gas. Opportunities for expanding the use of non-energy sources are being developed. There are indications that demand is falling for those food commodities that require large amounts of energy to produce. In this country, for example, rising energy costs throughout the economy have reduced consumer disposable income. As prices of energy inefficient foods such as beef have risen, consumers have curtailed their purchases of beef and switched to more energy efficient meats such as pork and poultry. Reacting to these market signals, farmers have chosen to produce more pork and poultry.Western Europe's imports of feed grains fell by 20 percent between 1960 and 1978, indicating that its demand for meat might have peaked. Other regions' grain imports have expanded during the same time period. However, with the exception of the Soviet Union and Eastern Europe, the bulk of this grain has been consumed directly by humans rather than being fed to livestock[5].

In certain instances, one market signal generated by the rising price of oil might be partially cancelled out by another market signal generated by the same event. This is certainly the case with biomass energy development. Energy cost increases will push up the prices of all food, including corn. This, in turn, will reduce the economic attractiveness of producing alcohol fuel from corn. For this reason, it is anticipated that alcohol fuels will satisfy only three to five percent of U.S. energy needs, rather than the higher percentage frequently claimed by biomass energy boosters[8].

Market sources affecting the food-fuel choice are likely to be both constrained and complemented by public policy. For example, individual countries have an interest in reducing their oil imports below the levels dictated by free markets. Taxes on imports or subsidies on domestically produced alternatives are two policy tools. Dr. Wallace Tyner of Purdue University agrues that the price of a barrel of imported oil fails to register the significant costs associated with dependence on foreign oil. These costs include "higher national security risks" and the loss of foreign policy-making prerogative[10]. This explains in part, the current 40 cent per gallon subsidy provided for domestic alcohol production.

However, the desire to reduce oil imports is not always matched by the willingness to accept the costs of doing so. For instance, increasing the degree of U.S. energy independence might require relaxation of reclamation requirements and clean-air rules since those policies discourage the mining and burning of coal. Similarly, soil conservation programs which encourage farmers to reduce the number of acres planted in corn might have to be de-emphasized for the sake of encouraging biomass energy development.

Aside from the environmental trade-offs implicit in attempts to reduce oil imports, many countries may find it difficult to develop biomas energy sources. A country which imports food and possesses little uncultivated arable land may find it unacceptable to trade off domestic food production for domestic energy production. In countries where hunger is a major problem, such a choice presents important ethical problems.

The impacts of single nation's trade-offs between food and energy cannot be contained within its borders. For example, Tyner points out that U.S. Alcohol production will reduce the amount of feed grain exports sent to Western Europe[10]. As that region seeks to replace that feed grain, it will affect food markets throughout the world. Conversely, if the United States continues to consume prodigious quantities of oil, it will perpetuate the economic conditions which allow for high oil prices.

Summary

In summary, rising energy prices will force us to continually reevaluate food-energy relationships. Consumers with constrained expenditure budgets, will be forced to greater selectivity of energy efficient foods. Farmers will need to adjust to these changing consumer demands and carefully monitor energy inputs to agricultural production. The public will need to make hard choices between using agricultural resources for food production alone or sharing these resources with fuel production. There is a very real need for continuing research and education programs to assist individuals and governments in defining alternatives and in making these choices.

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16.2

SYNFUEL PRODUCTION AS AN ECONOMIC FARM ENTERPRISE

by

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Abstract

Synfuel production has been forwarded as a partial solution to U.S. liquid fuel needs. Among the various synfuel alternatives, alcohol from crops (principally corn) and a diesel oil substitute from oilseed crops (such as sunflower) are the only near term possibilities that can provide significant quantities of liquid fuels before the 1990's. While most of the synfuel production will come from large commercial plants, farmers are keenly interested in fuel from on-farm biomass production units. They forsee another farm enterprise that will provide both additional income and a secure, stable source of fuel for carrying out agricultural production tasks in a timely manner. Therefore, farmers are asking questions concerning the techniques of energy production and seriously weighing the alternatives. However, farmers are also asking management question, such as "How will farm energy production affect other farm enterprises?" and "How will farm energy production affect the farm's labor and capital requirements?" In short, farmers want some assurance that not only is on-farm synfuel production technically feasible but also that it can be intergrated into the total farm business. Clearly, the answer will not be uniform for all farms since each farm has a unique mix of production, management and financial resources.

This paper describes a synfuel decision model (computer program) that will assist farmers and farm advisers in making an economic assessment of potential synfuel production on individual farms. It wil be accessible to individuals and groups on remote terminals and/or micro-computers. This generalized mathematical programming model allows users to describe their specific farm situation as an input to the program. The program then estimates the impacts of synfuel production on their particular farm, providing answers to specific questions surrounding the intergration of synfuel production into their present operation. Since farm production activity possibilities are region specific, this model incorporates two energy feedstocks sources that are potentially available in Ohio and the central and southern part of the Corn Belt generally. One is corn. The other is sunflower which is grown as a double crop following winter wheat. The model can be adapted to add other energy feedstock alternatives.

On Farm Energy Production Systems

In small-scale operations, 190 or lower proof alcohol is typically produced. To produce anhydrous (200 proof) alcohol, aezotropic distillation using benzene is required. This process is best performed by large operations and is not considered as a viable on-farm option. One bushel of corn will yield between 2.2 and 2.5 gallons of 190 proof ethanol. After removing the alcohol, 240 pounds of stillage remain for each bushel of corn. The stillage can be filtered and pressed to produce 37 pounds of wet distillers grains (WDG) and 203 pounds of wet distillers solubles (WDS). These products must be fed immediately or can be dried to produce 11 pounds of dry distillers grains (DDG) and 6 pounds of dry distillers solubles (DDS). Distillers dried grains with solubles (DDGS) has a 27 percent protein content as well as a longer storage life than the wet stillage and, as such, can be sold or stored and used as a livestock feed. Production of DDGS however, requires additional energy expenditure. DDGS may be fed in liberal quantities to ruminants (dairy and beef cattle), but high fiber and incomplete amino acids limit consumption levels for hogs and poultry. The ethanol produced from corn can be used on-farm in pure form or sold. On-farm use is often limited since most farm machinery is diesel powered. The model allows the sale option only.

Unlike alcohol, which requires a biological/chemical procedure, sunflower oil production is a simple mechanical process. It can be easily adapted to any scale and does not involve the high capital requirements of alcohol production. The seeds should be dehulled (optional) and pressed. The oil should be filtered. The non-alcohol nature of sunflower oil eliminates the alcohol processing problems of government regulations, large water requirments, environmental impacts, danger of explosions, and large energy requirements. Thus, oil production is more technically feasible for on-farm production.

Sunflower oil is used only as a diesel fuel replacement. Tests are still being conducted to determine the best usage of the oil - in pure form or combined with diesel fuel. The viscosity of the oil requires either mixing with diesel or butanol or a modification of fuel filtration systems. Between 85 and 105 gallons of oil can be produced per acre of sunflowers. After extracting the oil, a meal is left which has a 45 percent protein content. The meal can be used for beef, swine, poultry, and other livestock. If the seeds were not dehulled, the meal has a high fiber content and can only be used for ruminants. The model allows sunflower oil to substitute for on-farm uses of diesel fuel.

Crop and Livestock Production Systems

Energy crop production and use must compete favorably with existing farm enterprises. The common inputs are land, labor, capital, and energy. The crops considered are corn grain, corn silage, soybens, wheat, hay and sunflowers. Pasture land is also permitted but is assumed to be land not suitable for other crop enteprises.

Three types of livestock are permitted: swine, beef cattle, and dairy cattle. Livestock are included to demonstrate the usage of the by-product of synfuel production. Poultry can only use small amounts of the by-product so are not included in the model. Feed requirements for all livestock are in corn equivalents with a minimum protein constraint. The manure is recycled back to the cropland and a cost and energy value is associated with that. All livestock are sold.

Five types of swine production can be analyzed: (1) blocked farrow to finish, (2) continuous production farrow to finish, (3) blocked feeder pig production, (4) continuous feeder pig production, and (5) finishing production. All will be high investment, confinement systems. The blocked production systems have fluctuations in labor requirements and are used when the main farm activity is crop production with large labor demands during certain periods. Continuous production systems are found on farms more heavily involved in swine production or with more labor available. Beef cattle can be cow-calf or beef feeder enterprises. Only one type of dairy production is considered.

Model Formulation

The model objective is to determine the optimal mix of farm enterprises to maximize profit. A linear programming model is used. The requirements for a linear programming model are: there must be alternative courses of action, the alternatives must be interrelated through some type of restriction, there must be an objective which is explicitly stated, and the variables must be linearly related.

Within the model there are 138 activities. Each crop has multiple activities to accurately represent the timeliness of operations. For example, corn may be planted in three different time periods in the spring and harvested in three different time periods in the fall—a total of nine different corn planting-harvesting activities. Also, land preparation activities and post-planting operations (spraying and cultivating) may be done in several time periods, thus a total of 17 corn production activities are used in the model.

The model has 137 constraints. Land may be owned, rented, or some combination of the two. Maximum and minimum production levels may be established for each crop and livestock species to restrict production levels. Labor constraints restrict the labor available in each time period. Labor can be comprised of farmer's labor plus hired labor minus any of the farmer's labor hired out. Hired labor is assumed to be only 80 percent as productive as the farmer's labor. Tractor hours are a scarce resource only during planting and harvesting periods.

Land must be prepared for planting corn and soybeans sometime between harvesting in the fall and planting in the spring. Constraints which may restrict land preparation are land, labor, field hours, and tractor hours. Corn and soybeans are planted during several periods. Planting an acre utilizes an acre of prepared land which cannot be used again until after harvesting. Labor hours per acre and equipment working rates are constant for all planting periods. Post-planting operations are performed two and four weeks after planting, and all acres of corn and beans planted must have the post-planting step. This operation utilizees labor, field hours, and tractor hours.

Harvesting of corn and soybeans uses field hours, tractor hours, and labor hours. Combines may harvest corn or beans, and custom harvesting can be used when there is a shortage of labor or combine hours.
All beans harvested are sold immediately. Corn can be sold, dried and sold, or stored for usage in alcohol production or for livestock feed. The yield of each crop varies by planting and harvest date. Storage loss is accounted for by increasing the quantity required for the various uses. Harvested corn moisture is based on the harvest date, and all corn is dried to 15.5 percent mositure.
Corn silage uses the same prepared land and post-planting operations as corn grain. Silage can have own or custom harvesting and must be fed on the farm.

The other crops are handled in less detail. Wheat may be produced as a single crop or double cropped with soybeans or sunflowers. The wheat crop is sold or used as livestock feed. The double cropped soybean crop is treated exactly as the regular bean crop except that land preparation, planting, and post planting all take place in the same time period. Sunflowers are handled much as beans with the output going into sunflower oil production.

Each livestock system has minimum feed requirements in terms of corn equivalents and amount of protein. The feed ingredients (corn, wheat, oats, soybean meal, corn gluten feed, stillage, DDGS, and sunflower meal) are all evaluated for feed content. No land is required for swine and only pasture is required for cattle, since it is assumed that the livestock will use land not normally cropped.

Alcohol production requires corn, labor, and energy. Any other inputs (i.e., land and water) are assumed to be available in sufficient quantities to meet production needs. Due to the expected presence of livestock and high capital costs, alcohol is producted at a fairly constant level for the entire year. The alcohol is sold and the stillage may be fed wet to livestock or dried for sale or feed.

Sunflower oil production is not required to be a year-round opeation. The feed by-product nature and capital requirements do not dictate continuous production. The meal can be sold or fed to livestock. Labor, sunflowers, and energy are the inputs of most importance.

Interfacing the User and Model

The successful application of this model would allow the user direct access with miminum interference by others. Advances in remote terminal and micro-computer technologies permit individual users to own terminals or micro-computers. Or users in a county may have access to one machine through the Cooperative Extension Service.

In either case substantial effort is required in designing the proposed computer model. An interactive computer program is needed which prompts the appropriate input from the user. The computer model must be "idiot proof" with the user needing to know nothing of model design. It must clearly specify the needed input data, sort the data for that which is plainly erroneous, find a solution, and print the results in an easily understood fashion.

Technology has advanced rapidly in developing convenient, low-cost remote terminals. They have become lighter weight, less costly, and more reliable, and have higher transmission speeds. Capabilities such as internal memory for temporary storage, editing, and retrieval of data allow the user to manupulate data before transmission to a large computer system.

An emerging technological change is the use of micro- and mini-computers. With an investment of a few thousand dollars, it is possible to have a fairly extensive computer processing facility. Computer models, such as the one discussed in this paper, could be loaded on micro- or mini-computers. The user would receive the programs via diskettes or tapes that would serve as storage devices for the programs. To use the model, the user would load the diskette or tape, type a statement to load the program on the micro- or mini-computer, and then run the computer model.

Finaly, there is the possibility of "down-loading" programs to micro- or mini-computers. The central main frame computer would remain the place where programs are stored and cataloged. Clients would dial the main computer, select their program, and down-load it to their own machine. The program could then be run on the mini or micro-computer, using relatively little telephone connect time and central computer capacity. This alternative also would allow the micro- or mini-computer to serve simply as a terminal for some programs requiring the large computational capacity of the main frame computer.

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16.3

BIOMASS ALLOCATION MODEL; A TOOL FOR ENERGY EDUCATION

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Introduction

This computerized biomass allocation model can serve as a unique tool for teaching students some of the basic concepts concerning biomass and the role it can play in the energy market place. The system, which uses an optimization model, has been used to determine the most profitable allocation of biomass resources for producing fuels by thermochemical conversion processes. During sessions at a computer terminal, the student can solve biomass allocation problems assigned to illustrate specific concepts such as the percentage of a total regional energy demand which can be satisfied by biomass. The versatility of the model also makes it possible to change the data base by updating fuel selling prices (for example), and examining the impact that this change has on a specific allocation problem.

The following are some of the concepts which can be taught with the aid of this model:

- Nature of biomass
- Thermochemical conversion processes for converting biomass to gaseous and liquid fuels
- Availability of biomass by region and season
- Relationship of manufacturing costs to efficiencies of thermochemical conversion processes
- Percentage of the total energy demand which can be supplied by thermochemically converting biomass to fuels
- Gaseous and liquid fuels which can be generated from biomass using thermochemical conversion processes
- Market sectors which can use the biomass derived fuels

A word about optimization. The allocation model is based on optimization using linear programming. Optimization is the collective process of finding the set of conditions required to achieve the best results for a given situation. In this case, the computer selects the set of conditions which produces a maximun profit. Computers are often used when the number of variables and constraints are so numerous and complex that it would be impractical to tackle the optimization by hand. In this project, optimization has been used to produce a computer-oriented tool for energy education by determining the most profitable allocation of biomass resources to produce alternative fuels. Other situations where optimization has found application (because it has increased profits) include scheduling an airline or fleet of moving vans, blending grades of petroleum products in a refinery, traffic flow control, and optimization in chemical process control. The model shows the most profitable combinations of biomass feedstocks, conversion processes, and fuel products to serve the conditions in a regional market sector. The computer simplifies the selection of the most profitable allocation from a very large number of them.

Refer to Table I for a description of the large number of potential permutations and combinations be considered in a typical biomass optimization problem. Available biomass includes numerous woody and non-woody resources. The fuels which these resources can be converted to depend on the demands of the market sectors. The demands for, and the selling prices of the fuels vary according to market sectors and regions. Fuel products are derived by different thermochemical conversion processes and the costs of the products vary according to the efficiencies, the conversion processes, financing, and the costs of the biomass feedstock being reacted. For each of these processes and for each biomass, there is a manufacturing cost which must be considered in determining the most profitable biomass allocation. The model calculates the most profitable combination of these conditions for a particular allocation situation.

Materials and Methods

The biomass allocation system requires a computer, the data base, and the optimization model.

The existing software runs on the Gilbert/Commonwealth Corporate IBM 370 system which is accessed by means of a terminal and telephone line. Cards available from Gilbert/Commonwealth Associates, Inc. can be used to transfer the data base and the program to any computer capable of supporting Fortran IV. The program could also become available on a time sharing basis from a centrally located computer, however, if this central computer concept were employed, it would not be possible for users to change the data files.

Data Base

An initial data base was established from published information. The data base should be updated frequently. Categories of information included in the data base. The price information for biomass resources was derived from the SRI "Biomass Systems Analysis Study".[1] Non-woody and woody biomass availablility figures were derived from EPRI[2] and SRI[3] studies. Manufacturing costs for the biomass derived fuels in 1985 were developed by a computer program with data from MITRE[4] and Gilbert/Commonwealth.[5] Fuel selling prices for 1985 were obtained from various reliable resources. Demand data for the fuels in the various market sectors were also derived from an SRI[1] study. As described in the final report for the project,[6] provisions have been made in the program to update the data base as more and better data become available.

Biomass Allocation Model

The biomass allocation program has access to a marketing file and a converison process file. Upon execution of the optimization software, quantities of feedstock are selected from the available feedstocks for use in satisfying the fuel demands. The selection is based on profit optimization which depends on the biomass feedstocks (costs and availablilities), the conversion proceses (efficiencies and manufacturing costs), and the product fuels (selling prices and demands). For details of the linear programming model used to calculate the most profitable biomass allocation, the reader is referred to the final report for the project.[6]

Results and Discussion

As an educational tool for the student learning about energy and biomass and its conversion to useable forms of energy, the biomass allocation model offers some unique and interesting possibilities. Initially, the user should have a basic understanding of what an allocation model does and the fact that optimization in this case is based on maximum profit. He should study the "User's Manual" which is available in the final report for the project[6] and be given time to generate an allocation problem which can be presented to the computer.

After logging into the system, the first information which the user must supply is the "Region" where the allocation is taking place. As it is presently structured, the data base includes only four regions which were selected because they had both an availability of feedstock and a demand for the product fuels. Regions 1 (NY, PA, WV) and 2 (GA, AL, MS) have both woody and non-woody species, Region 3 (IN, IL, IA) has predominantly non-woody species, and Region 4 (OR, WA) has a predominance of woody species. In making this input, the user learns that the availability of biomass species is dependent on the geographical zone.

The second input is "Seasonal" preference (Summer, Fall, Winter, or Spring). The basic concept enforced here is that some non-woody crop residual biomass is only seasonally available. In Region 2, cotton waste is only available in the Spring, Summer, and Fall and is most abundant in the Fall. Cotton is not available as a fuel source in Region 1 (NY, PA, WV). This is contrasted to woody biomass species whose availability is more evenly distributed throughout the year.

Step 3 is to enter numbers corresponding to the biomass "Feedstocks" being considered. Because the number code for the various feedstocks is not printed out during the user input portion of a terminal session, the user must have the information about the biomass species available in the region and the corresponding biomass feedstock number code. The number code is available in the final report for the project[6] and in Table 1. This process forces the user to consider the most abundant biomass resources available. At the present time, 44 wood types and 17 non-woody biomass materials have been included in the data base.

Step 4 requires the user to choose market sector and product combinations to be considered in the allocation. The market sectors from which the user must choose include transportation, residential/commercial, chemical/industrial, and electric utility. Because each of the biomass derived fuels cannot be used by every market sector, the user learns which fuels apply to which market sectors. The computer will inform the user if an invalid market sector/fuel entry is made. Table 1 shows which fuels apply to which market sectors and the thermochemical conversion processes which are involved.

The final input required by the user is to either accept or change the percentage of total regional fuel demand which is to be provided by the biomass derived fuels. The percentage offered by the computer is 80%. The eductional message provided to the user at this point is that the total demand for fuels which can be supplied by thermochemically converting biomass is generally under 1%.

This is the extent of the user's input. The computer then searches for the most profitable allocation and prints it out. Examination of the results can reveal additional instructional information. The amount of each feedstock used and the amount which is available. During the summer season in Region 1, 0.1361×10^7 MMBtu of selected eastern white oaks is available and 0.5172×10^6 MMBtu is used to make product 17 (SNG) for the residential market sector where the product demand is 0.3600×10^6 MMBtu/Yr and the selling price is $5.037/MMBtu. In this case, a loss of 0.856×10^5 $/MMBtu occurs when the manufacturing cost is $5.28/MMBtu and the efficiency of the conversion process is 69.6%. On the printout, similar information is presented for the other feedstocks and products considered for the allocation.

The solution also provides information on product and fuel selling price. The projected 1985 FOB gasoline price of $8.02/MMBtu can be contrasted to the electricity selling price of $26.38/MMBtu. The user can see the relationship between the efficiency of the conversion process and the manufacturing costs.

The high efficiency (69.9%) inherent in producing SNG from biomass results in a manufacturing cost of $5.28/MMBtu. This is contrasted to a lower efficiency (31%) when biomass is directly combusted to produce electricity causing a manufacturing cost of $9.80/MMBtu. He can also see that biomass derived SNG costs more to manufacture ($5.28/MMBtu) than it is projected to be sold for ($5.037/MMBtu). The Biomass Allocation Model can also be used to examine how different fuel-product manufacturing costs can impact a given allocation problem.

Differences are seen in the most profitable allocation of hard maple and soft wood when the different manufacturing costs are used. In an allocation with 1980 manufacturing costs, soft wood is allocated for conversion to electricity. However, when the manufacturing cost for electricity is raised to the projected 1985 level, it is more profitable to allocate the soft wood to fuel oil for residential use. Like soft wood, hard maple was allocated to elecricity produced by direct combustionm when the low 1980 manufacturing cost makes it more profitable to do so. However, when the 1985 manufacturing cost for electricity is used, hard maple is reallocated to gasoline production.

Other scenarios can be created by other changes such as changing the data based for the fuel selling prices or conversion process costs. By doing this, the model can reveal the influences that these changes in the data base can have on the most profitable allocation of biomass resources.

Acknowledgement
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TABLE 1

INFORMATION CONSIDERED FOR CALCULATING BIOMASS ALLOCATIONS

1. **Biomass Feedstock**

61 Species of Wood and gricultural Residues

1. Oaks White (S.E. (S)elect, (E)astern
2. Oaks, White (O,E) (O)other, (E)eastern
3. Oaks, Red (S.E)
4. Oaks, Red (O,E)
5. Hickory (E)
6. Birch, Yellow (E)
7. Maple, Hard (E)
8. Maple, Soft (E)
9. Beech (E)
10. Sweetgum (E)
11. Tupelo/B. Gum (E)
12. Ash (E)
13. Basswood (E)
14. Poplar, Yellow (E)
15. Cottonwood/Asp.
16. Waltnut, Black (E)
17. Cherry, Black (E)
18. Hardwoods (O,E)
19. Alder, Red (W) (W)estern
20. Oak (W)

21. Hardwoods (O,W)
22. Longleaf/Sp (E)
23. Shortleaf/Lob, E
24. Pine , Yellow (O.E.)
25. Pine, R/W (E)

Pine, Jack (E)
Spruce/B. Fir (E)

28. Hemlock (E)
29. Hemlock (W)
30. Softwood (O,E)
31. Ponderosa/J. Pine
32. Firs, True (W)
33. Firs, True (W)
34. Cyprus (E)
35. Pne, Sugar (W)
36. Pine, White (W)
37. Redwood (W)
38. Spruce, Sitka (W)
39. Engelmann (O,W)
40. Larch (W)

41. Cedar, Red (W)
42. Cedar, Incense (W)
43. Pine, Lodgepole (W)
44. Softwood (O.W)
45. Wheat
46. Corn, Grain
47. Soybeans
48. Oats
49. Potatoes
50. Barley
51. Sugarbeet, Field

53. Rice, Straw

53. Rice, Straw
54. Sugarcane, Field
55. Cotton
56. Peanuts
57. Bagasse
58. Rye
59. Grasses, Seed
60. Hulls, Rice
61. Sugarbeet, Pulp

2. **Biomass Derived Fuels**

a. Fuels	Residential/ Commercial	Electric Utility	Commercial/ Industrial	Transportation
	Market Sectors			
Low Btu Gas		x	x	
Medium Btu Gas	x	x		
Fuel Oil	x	x	x	x
Electricity	x	x	x	
SNG (Synthetic Natural Gas)	x	x		
Ammonia			x	
Methanol		x	x	x
Gasoline				x

b. Regional demands for fuels by market sector in trillion Btu

c. Regional selling prices by market sector in $/million Btu

3. **Regions**

a. Region I: NY, PA, WV

b. Region II: AL,MS,GA

c. Region III: IA, IN, IL

d. Region IV: WA, OR

4. **Thermochemical Conversion Processes**

a. Processes

Medium Btu Gas from Oxygen-Blown Gasification
Low Btu Gas from Air-Blown Gasification
SNG from Shift and Methanation of Medium Btu Gas
Ammonia from Shift and Ammonia Synthesis via Medium Btu Gas
Methanol rom Shift and Catalytic Methanol Synthesis via Medium Btu Gas
Electricity from Direct Combustion; combined Cycle Plant via Low Btu Ga or Med. Btu Gas, or Gas Turbin via Methanol
Gasoline from Catalytic Synthesis from Methanol Derived from Medium Btu Gas
Fuel Oil from Pyrolysis of Biomass

b. Efficiencies and manufacturing costs using different biomass feedstocks.

16.4

METHANE GENERATOR: AN EDUCATIONAL AND RESEARCH RESOURCE

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Abstract
An interdisciplinary research project on methane generation by anaerobic bioconversion was initiated by the Office of Special Studies of the College of the Holy Cross, Worcester, MA in 1974. It was open to the undergraduates from the College, Clark University and Worcester Polytechnic Institute. So far nearly 100 undergraduates have participated in this project. The participants had diverse adacemic backgrounds viz. biology, chemistry, physics, engineering, humanities and social sciences. They conducted multifaceted investigations such as a resource survey of dairy farms of Worcester County, studying the feasibility of generating methane from paper and food scraps of a university, generation of electricity from manure on a dariy farm and so on. A modular continuous-type methane generator was designed, its economic analysis was carried out and it was found to be profitable. Our conclusion is that methane generation is profitable both in small and large-scale and, that it admirably supports a durable rural economy. Technology is available for converting waste into methane. The process generates multiple benefits viz. reduction of pollution, generation of a clean fuel, sustenance of agriculture and promotion of a recycling economy.

Learning is an enjoyable enterprise. The institutions of higher education create learning environment by providing professors, laboratories, libraries and frequent opportunities for varieties of intellectual challanges. The content and implications of knowledge are continuously changing. Therefore, the higher education process should aim at developing the ability of the students to learn by enquiry, investigation and analysis. The Panel on laboratory in Biology of The Commission of Undergraduate Education in the Biological Sciences concluded that the highest priority in college curriculum was to engage the sutdents in the process of investigation[1]. Until recently, this approach to college education received support from the Office of Experimental Projects and Programs of the National Science Foundation. This paper summarizes a project, Interdisciplinary Research on Methane Generation that has been conducted since 1974.

The project was initiated by us in association with the faculty members from the College of the Holy Cross, Clark University and Worcester Polytechnic Institute. It was open only to the undergraduates of these institutions without any restrictions on their academic backgrounds. The project was originally supervised by a physicist, a chemical engineer and two microbiologists and it had input also from an electrical engineer, an economist and a dairy specialist. The project is being carried out as an Interdisciplinary Research course in the Office of Special Studies, College of the Holy Cross, Worcester, MA. During the last 7 years nearly 100 undergraduates have participated in the project. The students earn academic credits for one or two semesters and grades are given. Each student conducts an investigation under the direction of an instructor. They meet with the instructor once a week and each of the students is required to submit a weekly report. These reports are discussed at the meetings. The students are also required to submit a final report and are encouraged to present their finding in the form of seminars. The emphasis has always been on learning to investigate, setting up experiments, developing library skills and carrrying out impartial analyses. The validity of a large number of student findings are questionable. Some students, however, have done creditable work and they have published them. It was the impression of both the students and the faculty involved in these studies that they derived a degree of satisfaction that no other course could provide.

Generation of Methane by Bioconversion

When organic matter decomposes under anaerobic conditions gases are produced which, under ideal conditions, consist of 60-65% methane, 35-40% carbon dioxide and traces of hydrogen, hydrogen sulfide, and nitrogen. This gas is flamable and it is popularly known as biogas. Ancient legends of "Will-O'-the Wisp", "Fool's Fire" are dancing flames ignited and drifting over the bogs and marshes (marsh gas). It is generally recognized the Alessandro Volta was the first to record the production of a flamable gas from lake sediments in 1776. As early as 1886 gas from anaerobic sewage digester was used to light a street in Exeter, England. Anaerobic digestion as an efficient process for stabilization of sewage sludge was developed throughout the world. By 1940 technical studies were conducted by Barker, Bushwell and others in the U.S.A. and by Acharya in India[2,3]. In 1939, scientists at the Indian Agricultural Research Institute, New Delhi, had developed a very simple methane generator. It was subsequently developed into a continuous-type combination gas generator and collector by Mr. Jashubhai Patel. The generator was so simple that an uneducated farmer could operate it. An uncle of B.T.L., Mr. G. M. Manjanathaya, Coorg, India had Mr. Patel install a methane generator on his coffee plantation in 1952. We have followed the operation of that generator ever since. It is a two-stage generator and produces about 400 ft^3 biogas daily from cattle manure. It has been working continuously for the last 29 years. According to Mr. Manjanathaya it has proved to be his backyard gold mine! There are over 80,000 such methane generators in India[4]. Biogas plants are also found in Taiwan, Korea, People's Republic of China and elsewhere. In the U.S.A. several reports of economic analysis have been published that are unfavorable for the production of methane by bioconversion. Yet, several generators have been set up in recent years[5]. We find that methane generation is applicable to both small and large-scale production. It also can serve both the developed and the developing countries.

All kinds of organic matter can be subjected to bioconversion to produce methane. There are, however, several factors to be taken into consideration. Most plants are high in carbon and most animal matters are rich in nitrogenous substances. A carbon to nitrogen ratio (C/N) of about 25:1 is an ideal combination for methane generation. For example, paper contributes only carbon and no nitrogen; C/N ratio of human fecis is 1:10, of cattle manure is 25:1, clover is 27:1, and of wheat straw is 150:1. This means that materials such as cattle manure and clover can be fed into the generators without any amendments, human fecis will require addition of cellulosic materials and straw will require nitrogenous amendments to make them suitable for bioconversion into methane. This is readily accomplished by appropriately mixing the nigrogen rich materials with carbon rich materials. Usually organic matter is pulverized and mixed with water to 12% solids (dry weight) or less. The slurry is fed into the generator and maintained at about 40°C under anaerobic condition. Then, several different microorganisms begin to grow and start degrading the organic matter. The process can also be operated at 55-60°C (thermophilic process) but it will not operate below 15°C. The organic matter must also contain abundance of cellulose and a pH between 6-8. Substances such as sulfur, chlorine, mercury, copper, various antibiotics, pesticides, and organic solvents are harmful to the process.

The initial microbial activities result in the breakdown of polysaccharides, proteins and fats into acetic, butyric, propionic and other acids, alcohols, carbon dioxide and hydrogen. These compounds are acted upon by the methane bacteria as they are produced and the end-product is a mixture of methane, carbon dioxide and traces of minor gases. The gas can be used as fuel without purification. Under appropriate conditions 40-60% dry weight of organic matter is degraded in about 20 days. The residue has a mild marshy odor and it has excellent fertilizer value. There is a large literature on the process.[6]

Areas of investigation

Biomass. Characteristics of domestic and agricultural wastes; energy values; cost of production, collection and preparation for bioconversion; chemical and biological characteristics of the spent slurry; and field surveys.

Generator Designs. Horizontal, vertical, plug flow, lagoon types, fiberglass & concrete digester; testing the effects of temperature, insulation, stirring, and retention time; disposal of slurry; collection and storage of gas.

Fermentation. Fresh and spent slurry analysis; total and volatile solids; monitoring changes in dry weight, pH, fatty acids and gas compositions; dosage response measurements on gas production; C/N ratios; and effect of toxic chemicals on the process.

Microbiology. Anaerobic bacteriology; enrichment cultures; survival of pathogens; effect of treatments and amendments on gas yields; and effects of slurry on soil microbes and on plants.

Resource Management. Surveys of college campuses, farms, the towns and cities and the region; economic analyses and feasibility of using methane generators.

Description of Specific Studies

1. Methane generator potential on a college campus[7]. The nature and potential of food scraps and paper generated on Clark Univesity campus was studied. The collectable paper contains about 40% carbon (90% cellulose) and no nitrogen. The food scraps (20% solids) contain 91% carbon and 9% nitrogen. When 36 lb paper is mixed with 50 lb of food scraps it wil give 30:1 C/N ratio. There was a potential to produce 11,000 ft^3 methane per week. The cost of building a generator was $20,000. At the natural gas prices of 1975 ($1.80/$10^6$Btu) the operation would lose about $3,000 per year. No credit, however, was given to the spent slurry and the possible educational uses of the system for energy related studies.

2. Potential for methane generation on a dairy farm[8]. This study was conducted in cooperation with the County Extension Service. There were 270 dairy farms in the Worcester County of which 34 were surveyed. A questioneer of 50 questions were developed under the headings, Farm Facts, Manure, Fuel Usage, Farmer's Knowledge about Methane Generation and General. The survey indicated that the median size dairy farm in the county had 65 cows. Methane generation process was known to most farmers but they considered the process still experimental. Nearly 1/3of the farmers were willing to invest $20,000 if the pay-off time is 10 years. Nearly 50% of the energy used on the farms is electricity. Therefore methane generated on the farm will have to be used for producing electricity. Direct uses of gas will require considerable alteration of equipment. Dairy farmers are already over working; each farmer works on the average 80-100 hours per week. Therefore, they have to be careful in what they are getting into. Average farmer is 47 years old. Young people were not staying on the farms. By an large, individual family-owned dairy farms are threatened by the economics. Yet, the majority of farmers were not willing to change their life-style. Manure is very important to the farmers as fertilizer. They also have land and equipment to dispose off the residue profitably. Methane generation will improve the quality of environment on the farms. These are attractive selling points. What is needed is a demonstration of a working generator to convince the farmers.

3. Economics of methane generator on a 65-cow dairy farm[9]. For this study a 20,000 gal fiberglass under-ground tank and a 6.5 kw electricity generator were considered. Such a system was found to cost $26,000 to install and $1,600 per year to operate. The system would generate benefit of $3,865 per year. It was an optimistic economic analysis. Most similar studies do not show that methane generation is profitable[10].

4. Feasibility of bioconversion power plants to generate methane was studied[11]. Algae ponds producing 130 lb/acre/day will require 500 ft^3 digester volume per acre. Algae can also be grown in special "Sunlite" tubes (manufactured by Kalwall Corporation, Manchester, NH). Three acres of algae pond or ½ acre of "Sunlite" tubes can produce enough methane to generate 5-7 kw electricity for 24 hours a day. The algae produced in tubes were 6 times more expensive than those from ponds. Although, biomass yields from 210,000 square miles of algae ponds can produce all the electricity needs of the U.S.A. cost of electricity so produced will be twice as expensive as the prevailing utility costs.

5. Feasibility of plastic films for gas collection and storage[12]. Plastic films are light weight and easy to fabricate and to repair. They may be made differentially permeable to carbon dioxide. This will aid in the passive purification of biogas. The work was carried out in association with a local manufacturer. New materials such as Kevlar (which has tensile strength greater than steel, pound for pound) can be used as outer covers for inflatable bags to hold gasses under pressures up to 200 psi. Six clylinders, 1½ ft diameter and 4 ft long, can hold 500 ft^3 gas which is equivalent to 2 gal of gasoline. These inflatable cylinders can be adapted for use on farm tractors and machinery. They will provide added attraction to the farmers. Plastic films have also been used in the construction of large lagoon or plugflow type of methane generators as well as collecting and storing the gas.

6. Feasibility of methane generator on a dairy farm to produce electricity were analyzed by Feldman and Breese[13]. It was based on a 65-cow dairy farm. The proposal was studied under three separate scenarios: 1). 45.6 m^3 digester and 12.5 kw electricity generator. 2). 76 m^3 digester and 30 kw generator and 3). the same as scenario #2 but selling the excess power to the utility. They found conflict between the best option for the utility and the farmer who produces methane. The utilities enjoy several hidden subsidies which are not available to the farmers. Although the utilities will suffer shortfalls under scenario #3, there will be decreases in utility capacity and fuel costs. It is beneficial to the national economy. Therefore, it may favor legislation enforcing marginal cost pricing of electricity and subsidies for installation of methane generators.

7. Economic analysis of family-size methane generators weas made by Lingappa and Lingappa[14]. Based on the information generated with a 20 gallon continuous-type methane generator a 300 gal generator has been disigned for modular operation (Fig. 1). By clustering 3 such generators up to 320 lb of manure can be processed daily. The evaluation was based on the assumption that the gas is used directly for burning without purification, credit is given to the slurry for use as fertilizer and labor for installation is supplied by the owner. It is tied into manure disposal system and requires no additional labor. It was shown that the original investment of $2,000 material cost may be recovered in 6 years and gas valued at $550 per year will be available free, thereafter.

Interdisciplinary Nature of the Subject

Students who participated in this project were already interested in environmental protection. They were further guided to keep their minds open to the influence of technology on lives of people. Presentations along the following lines are made to them periodically. Although rate of population growth has decreased world population will exceed 6 billion by the year 2,000, in terms of numbers 100 million more human beings will be added every year. Most of this increase will take place in the poor countries of Asia, Middle East and Africa. As a result gap between the rich and poor nations will widen. Although, food production will actually increase during this time, per capita consumption of food may actually decrease in poor countries[15]. World oil production capacity will have levelled off and the proor may not be able to afford firewood. The forests and woodlands are decreasing at the rate of 20 million hectares every year. Soil erosion, loss of organic matter, ubranization and desertification are taking increasing toll of agricultural land. Our water and air will be further threatened by icreasing pollution. Increasing uses of coal and nuclear energy will increase environmental pollution and health hazard.

Between 1950 and 1960 yield of corn per acre doubled but the fossil energy spent in producing of food grains in the U.S. go to feed the meat animals. Such changes in production and consumption and the population increase result in greater demands on energy, land, water and other resources. Modern agriculture is ecologically destructive. Agriculture is the major nonpoint source of water pollution. Although, only 10% of the cropland is irrigated, it accounts for 80% of water consumption. Agriculture is also a major contributor of soil erosion- in 1976-77 wind erosion of soil in the Great Plains was comparable to the Dust Bowl of 1938-39.

The world is facing a series of crises directly related to the production and uses of energy. Of all the types of energy, methane production from anaerobic bioconversion is the least damaging to the environment. Not only it uses the waste organic matters which otherwise pollute the environment, but also, it generates the residue which is an ideal soil conditioner and fertilizer. The gas that is produced in this transformation is nonpolluting. Methane-centered agriculture has the greatest recycling potential. It has been said that 5% of the biomass produced on earth can meet the fossil fuel needs. The U.S. generates nearly a billion tons of waste every year which can produce energy corresponding to 77% of U.S. oil imports[16]. Better utilization of biomass is an option that is available for balanced development in the future for which technology is available. Examination of this option involves many aspects of life and is eminently suited for an interdisciplinary research.

Concluding remarks

The project was found to satisfy several needs of the undergraduates viz.

1. It gives them an opportunity to investigate about a process or a product the significance of which is easily understood.
2. They develop much needed laboratory and library skills.
3. They get to interact with students of different academic backgrounds and with the general public.
4. And, it gives the students and opportunity to express one's achievement in the form of a written report and as a lecture before an audience.

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SESSION 17: ARCHITECTURE AND URBAN PLANNING

17.1

Education on Solar Energy in Architecture in Colombia

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Abstract
The Universidad Nacional De Colombia is the hub of Solar Energy education in the country; it maintains a continuous activity in this technological field. The Department of Physics deals with photovoltaics and selective films, the School of Engineering studies heat transfer and industrial application, and the School of Arts has to do with Solar Architecture at its Department of Building Construction.

A course for teaching Solar Energy in Architecture was established in 1977 with a program encompassing five main parts: Analysis of the World Energy Crisis, Physical study of the sun, Direct and difuse solar radiation and active and passive solar systems, Construction of working models of solar systems for heating and cooling, Design of solar buildings. The methodology for this course includes audio-visual aids and practical teaching at the workshop. The course, originally planned for one semester, will be expanded to three semesters, starting in 1982.

Besides this strictly educational activity the Universidad Nacional De Colombia organized in 1978 a Solar Energy Committee, formed by 12 professors from different schools of the University. The main task of this committee is the organization of seminars and public conferences in Bogota and other cities in the country in order to spread knowledge on solar energy and its applications.

Text
Before going into the core of the theme of this paper, it seems appropriate to say a few words about the Universidad Nacional De Colombia which has become the hub of Solar Education in Colombia. The Universidad Nacional De Colombia was the first institution for higher education established in the country; its foundation in Bogota goes back to 1867 when it started with a handful of departments. The University nowadays counts 14 major schools, offers 90 career choices, and operates in four main cities.

The Universidad Nacional De Colombia is autonomous and it is the sole State University in the country, being the only one at the reach of students from the lower income bracket. There exist several other universities in Colombia but most of them are private, for students from the higher income class. The Universidad Nacional ruled by a Board of Directors called "Consejo Superior Universitario," formed by the Ministry of Education, the Rector of the University, a dean on behalf of the faculty, and members representing other sectors of the University and the Government.

The University facilities are not large enough to allow the enrollment of all those who want to study there; however, some 25,000 full time students attend daily classes, 18,000 of them in Bogota.
Though in terms of the number of students this is not a real large university, it does strive for high quality of education, and it is well known for having a keen and continuous interest in maintaining up-to-date teaching.

The concern for Solar Energy at the University began in 1976 as a result of energy problems. Colombia had been an oil exporting country until 1975, becoming a net importer the following year. At this time a few people at the UNIVERSIDAD NACIONAL became aware of an impending need for energy conservation and for the development and utilization of renewable resources.
Those few people, all professors of the University, have been the pioneers in the field of Solar Energy Education in Colombia. They made Solar Energy an important issue, first within the university and then amongst the general public by means of seminars and conferences. In this way the Universidad Nacional became the leader in Solar Energy Education in the country. In the late 70's Solar became a novel technology at the University and a number of its departments got involved in the study, research, and application of new technics in this area.

Due to the fact that there are different grades and modes of Solar Energy applications, the teaching of this subject takes place in different sections of the University.
The Department of Physics (School of Sciences) studies photovoltaics and selective films for collectors. The School of Engineering deals with heat transfer and industrial applications, and the School of Arts has a new subject within the curriculum for teaching Solar Energy in Architecture.
One might wonder: "Why there exists an interest for Solar at a School of Arts?" - The remainder of this paper deals with this question.

The former School of Architecture was founded in 1936 and remained as an independent school until 1965; in this year it was brought together with the School of Fine Arts and the School of Music to form the present School of Arts. In that way Architecture became a career field within the newly formed school. Nevertheless, teaching of building construction, architectural design, urban planning, etc., continued in full strength as before, in its five departments during a period of ten semesters.
The technical side of architecture is taught at the Department of Building Construction. This department was the cradle for Solar Architecture in Colombia, when in 1977 this subject was created. Actual classes began in 1978 for a course of one semester.

The program originally established for this subject includes theory, workshops, and designs of solar architecture projects.
This program encompasses five distinct parts:

a) Analysis of the World Energy Crisis as a state of global uneasiness.

b) Physical study of the sun. Its amazing performance as an almost everlasting source of power.

c) The way solar energy reaches the earth. Direct and diffuse radiation. Methods of collection, storage, and distribution of thermal energy - passive and active systems.

d) Workshop for construction of models for active systems for water heating and passive systems for space heating and cooling.

e) Examples of solar architecture in different parts of the world - Need for proper design according to latitude and climate.

A few words must be devoted here to dig deeper into the substance of this program and the methodology devised for teaching this new course. The reason for starting the subject wtih the analysis of the World Energy Crisis is to prepare the student's mind for a clear understanding of the seriousness of the energy situation. The energy crisis is not local by any means, it is a global concern affecting all mankind.

Amongst the many factors that could be attributed to the emergence of this so called Energy Crisis, are five which deserve careful study. Without going into detail, it seems convenient to mention them in a special order to see the logical inter-action among each other. These factors of paramount importance are:

1. Swift growth of world population.
2. Global mechanization as a result of technology.
3. Rapid increase in growth and demand of energy.
4. Fast exhaustion of non-renewable resources.
5. Restrictions on production and use of energy owing to environmental pollution.

A good deal of time is devoted in analyzing the role these factors play in the energy situation, in order to awake a favorable attitude in the student towards the urgent need for seeking renewable and non-polluting resources.

The student must understand that the world faces a transition period toward new sources of energy and that the present dependence on oil will come to an end soon.

At this point of the course there is a clear understanding that the sooner man can get away from energy based on petroleum the better. The time is ripe then to talk about the new resources available to mankind, now and in the near future: namely geo-thermal and ocean-thermal energy, hydrogen, nuclear fusion, and solar energy, just to mention a few.

Solar energy is at hand now and ready for use. As a matter of fact it has been in use for some years now; solar stills were known in the last century, and scattered solar collectors have been around for 50 years.

When actual teaching of solar energy begins, this part of the course starts with a very important statement: "Solar Energy has been the prime source of life in this planet from the very beginning and it cannot be said that it is a new source of energy. However, the techniques for its artificial utilization are new."

It comes then, as a matter of common sence, that an explanation of the nature of the sun and its amazing performance is required. It is surprising how few people know about the sun, and the way it produces immense, prodigious, and everlasting (on a human scale) quantities of energy; the sun has just been taken for granted.

The next step in the course is to explain how solar energy reaches the earth through space and across the atmosphere, as direct and difusse radiation.

The students attending this course, at this moment would possibly want to know much more about Solar Energy and its implications in solar architecture design.

Before going into the actual design of solar projects, the student must learn about active and passive systems and the way they could be incorporated into solar building design.

Here the workshop comes very handy because the actual construction of working models enables the student to learn the hidden secrets of solar collectors, trombe walls, cooling roofs, latent and sensible heat storage, etc., and also how efficiency and cost can be balanced. This part of the course takes several weeks during the semester because models have to be made by the students themselves and then tested.

To close the course, we finally come to the actual design of a solar house. In Colombia there are no seasons like spring, summer, autumn, and winter; the climate varies according to altitude above sea level. Therefore in solar design it is necessary to plan for warm buildings in cold climate, at altitudes of 8,000 to 10,000 ft., and cool buildings for altitudes ranging between zero and 8,000 ft. above sea level. Moreover, for the warmer areas it is necessary to know whether the climate is hot dry or hot humid, since in the later case cooling is more difficult.

Design of solar architecture is governed by the sun path. In the higher latitudes of the Northern Hemisphere the sun shines from the south all the year round, and therefore the facades facing south are the important ones for solar collection. In the Southern Hemisphere, as in Argentina and Chile, it is the reverse and facades facing north are the ones to be considered. In the Equatorial Zone, as in the case of Colombia, the walls facing east and west are the ones which receive solar radiation every day, whereas south and north walls receive no sun at all, alternately, during some periods of the year. The roofs, instead, are heated day by day by an overhead sun.

Space heating is not the main issue in Colombia - Though it is desirable to have comfortable warm buildings in Bogota and other cities located at 9,000 ft. and over, above sea level, we can go by without any heating at all, because at that altitude the climate is springlike all the year round. If solar heating would be required it could easily be achieved by means of trombe walls or by glassing some areas of the roof, thus creating a greenhouse effect.

Cooling is more important in Colombia, as 90% of the towns and cities are located in lower lands where a warm or hot climate is prevalent. Double roofs, vertical and cross interior ventilation, and cooling walls by evaporation of water and the issue. Also insulating construction materials are considered in this part of the course.

Solar air conditioning by thermal absorption refrigeration systems using ammonia or lithum bromide water solutions, and solar air conditioning by compression utilizing a solar engine to drive the compressor are also mentioned in the course in some detail. However, these methods of air conditioning are far too expensive and they are not in use in the country yet.

In Colombia the sun path propitiously enhances passive systems in solar architecture, both for cold and hot climates. Consequently, there are room for developing a bio-climatic type of architecture.

Solar Architecture has gained great acceptance among students and faculty as well, at the School of Arts, and this course which is at present one semester long, will be expanded to three semesters starting in 1982. The new program includes one semester for construction and research of prototypes for hot and cold climates, and the third semester will be devoted to computer science applied to solar design.
Because this course for architects involves special technical matters, we have the assistance of professors from the School of Engineering and the Department of Physics, who will come to the class-room to deliver lectures on particular topics.

The Universidad Nacional De Colombia has interest in spreading the knowledge on Solar Energy amongst other universities and the general public. To attain this goal the University organized in 1978 a Committee on Solar Energy formed by 12 professors belonging to departments involved in the study, teaching, research, and application of the new solar technologies.
The main task of this committee is to organize public conferences and seminars in Bogota and other cities in the country.

In this time of energy shortages the sun appears shining brighter for all mankind, and we in Colombia are trying hard to teach our students to use it in our architecture to conserve valuable resources. We hope to succeed.

17.2

LINKING URBAN PLANNING AND ENERGY

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Abstract
The use of urban planning tools and techniques to address energy issues is a newly evolving focus for planning professionals and educators. The enery shortage has been viewed as solvable or corrected primarily by engineering or architectural approaches. Clearly, however, land use configurations, zoning and subdivision regulations, and other planning devices have a significant impact on all aspects of energy usage--supply, demand, efficiency and conservation.

A need exists to incorporate "energy consciousness" into the planning field, particularly in professional planning education. However, energy issues are not as yet part of standard planning curricula in the United States. This paper presents the experiences of a professional planner's design and teaching of a precedent-setting graduate-level energy course for planning students. Initially offered as an experiment for one semester, students' enthusiasm prompted the repetition of the course.

The course explores energy-efficient planning techniques to reduce consumption of traditional fuels and increase the use of renewable energy sources. The paper highlights the challenges involved in curriculum development; analyzes the strategies used to integrate the multi-disciplinary aspects of both planning and energy; evaluates the technique used in teaching students with diverse professional backgrounds; and assesses the course's achievements in terms of defining those areas where intervention by planners can be most effective.

Introduction
The purpose of this paper is to examine the experiences of structuring and teaching an introductory course on energy in graduate planning school. Before I do that, however, first I should position planning within the general energy field, and second, more specifically explain the link between urban planning and energy.

The energy problem was originally perceived as an OPEC curtailment/supply shortage issue. A natural response was a technical engineering approach to increasing fuel production. The next professionals entering the picture were architects, who addressed their attention to the single end use: the building, its orientation, insulation, and insolation. Then the building was related to the site, which led to studies of wind breaks, vegetation, slopes. Site design mainly applies to rural and suburban areas, where most buildings are detached and one or two stories high.

Next, to understand the relationship between energy and high density attached medium to high rise urban areas, technically oriented studies concentrated in computer simulation analyses of *ideal* energy-efficient communities.

The reality, however, is that energy is largely consumed in *existing* urban settings. Planning is the field that deals with the already-built environment. One characteristic of this built environment is a rigid layout that ignores nature -- orientation, topography, winds, latitude, altitude. One of the main reasons for this rigidity is that urban design is controlled by planning guidelines and regulations: zoning, subdivision regulations, land use, site plan review, capital improvement programs.

Originally designed to protect the health and welfare of the people (zoning requires natural light and ventilation; exclusionary land use separates residential areas from areas with obnoxious industrial pollution; subdivision regulations prohibit very steep roads; capital improvement program provides potable water), these regulations became accepted and enforced during a period of - what we thought - endless energy supply.

Nevertheless, present regulations negatively impact on energy, social, economic and other factors. For instance, land use plans have historically separated functional sectors, forcing excessive trip-to-work traveling; site review has determined building location independently of orientation; zoning has encouraged shopping centers in detriment of local economic development; subdivision regulations have demanded superfluous street widths; capital improvement programs propelled urban sprawl by expanding roads and sewer systems. Moreover, the interaction of all regulatory effects compounds problems. For example, physical decay of an area is interwoven with unemployment, crime, as well as energy-*inefficent* housing.

All these considerations indicate that understanding the interdependency between planning regulatory tools and energy was paramount for planning students.

Course purposes
The orientation of this course was the critical analysis of (a) the legal constraints to a more energy-efficient urban fabric and its socio-economic repercussions, and (b) of the opportunities and possibilities to modify regulations considering the inclusion of conservation and use of alternative energy sources.

Given two factors, that planning is essentially an interdisciplinary field, and that students come from diverse professional backgrounds, the regulatory aspects work as a common denominator and language. Its analysis and evaluation are means to attain the main purpose of teaching: to develop and enhance students' thinking capacity.

Teaching technique and structure
The teachnique used in this course was a mix of alternating lecture and seminar/discussion sessions. This mix provides for external input -- lectures --, and internal input -- discussions on required readings and student presentations on individual projects.
The course was structured in three segments: Introduction to energy problems and solutions; energy alternatives and applications; and student projects.

The first segment had two parts. The introductory lectures summarized the meaning of energy; fuel conversions; energy consumption by conventional fuels and by sectors; renewable energy sources (solar, geothermal, etc.,); alternative technologies (heat recovery, cogeneration); energy conservation; and energy efficiency (1st and 2nd laws of Thermodynamics). Emphasis was placed on considering conservation as a resource and on understanding entropy and the importance of its use.

The second part, class discussions on readings, evolved around socio-economic-political impacts of the traditional use of non-renewable energy resources; energy alternative proposals; and assessment of energy plans and policies. Barry Commoner's *"The Politics of Energy"*[1] was the basis for this first discussion because this book approaches all these issues in an analyical-critical-integrated manner.

The next discussion was on the book *"Using Land to Save Energy"* by Corbin Crews-Hardwood[2], up to now the most comprehensive analysis of planning regulations, legislative constraints, amendment possibilities, and new proposed and applied regulations, all of them in view of their effect on energy usage and their socio-economic-environmental consequences, but mainly in reference to new communities. This latter limitation was somehow overcome during the discussion with examples and analysis of existing urban cases.

Planning is a system that involves many disciplines. Its implementation, however depends on political decision-making and public policies; therefore, students were encouraged to be critical and comprehensive. For instance, if planners propose that cluster developments with a community energy system and a mix of land uses and densities are required near intermodal transportation centers, students were asked what type of planning regulations would implement that proposal; what type of enabling legislation was needed; what type of land use would provide for a socio-economic mix; how, why and where energy use could be reduced, made more efficient or be provided by alternative sources; and what were the political constraints.

The second segment of the course dealt mainly with alternative sources examined by the guest lecturers. A totally solar scenario was explored as a solution applicable to suburban development. This led to the discussion on issues such as pricing, availability, urban vs. suburban lifestyles, role of corporations and utilities on centralized energy systems. Cogeneration and heat recovery was approached in a more technical way. A comparative study on conservation and energy policies in the U.S.A. and European countries allowed for a more integrated approach to the many factors and issues related to energy and planning. Two New York City lecturers dealt with the political constraints to implement an energy plan for the city, the array of available possibilities in using renewable sources and their impacts, and an analytical review of community based experiences on appropriate technology.

The third segment was dedicated to the progress report presentations and class discussion of individual course projects. All papers related legal/regulatory aspects of planning with energy in topics that varied in scale -- from analysis of an industrial park to a state plan; in specific sectors --transportation, employment; in scenarios -- urban, suburban; or in type of approach -- technical study of solar access. In most cases the multi-disciplinary characteristic of planning was an integral part of both the analysis and proposals.

Course evaluation
It was appropriate to emphasize the correlation between land use and energy and to use the seminar-discussion format interspersed with lectures. It was also convenient to concentrate the guest lecturers in the middle of the course so as to give the students time to start working on their projects. The discussion on the projects was valuable because it added information and helped the students in the development of their individual papers.

In mid-semester, part of one class was dedicated to an assessment of the course. Students positively evaluated the course content and format but expressed the need for an expansion of the time devoted to introductory lectures and discussion sessions on required readings.

Next semester the course's orientation and substance will be maintained. Students lacking a planning background learned about processes, systems, comprehensivenes, physico-socio-olitico-economic-environmental-energy interdependency, including the professional jargon. In addition, advanced planning students realized that energy planning is essential and must be incorporated into the school curriculum and their future professional practice.

Conclusion
All students come to the understanding that:

- Conservation is the most accessible and implementable energy resource;
- Conservation could greatly reduce energy usage, is cost effective, labor intensive, and, thus, could help resolve many of the problems of highly urbanized areas, particularly those almost totally dependent on non-renewable fuels, such as New York;

·Solar, methane, solid waste, cogeneration and other renewable fuels and energy alternatives are also available;

·Postponing the use of these possibilities will only exacerbate socio-economic and physical deterioration;

·Political forces, and not technical questions, determine the supply, demand and consumption of energy;

·And, finally that planners should have an active role in incorporating energy-efficiency in the design of land use plans and implementary programs.

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17.3

A PIAGETIAN APPROACH TO THE DEVELOPMENT OF ENERGY CURRICULA IN SCHOOLS OF ARCHITECTURE

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Abstract
Energy-conscious design has been a topic of increasing concern to the architectural profession. The general response in schools of architecture has been to add technology courses to the curriculum and to incorporate energy-related problems into the design studio. Even with these efforts, however, students do not appear to adequately understand energy principles or know how to apply them to the design of buildings. We feel that these courses are not as productive as they should be because they do not take into account the cognitive abilities of architectural students. Architectural design is dominated by visual problem solving processes that are not appropriate to the analysis of energy issues and the utilization of frequently abstract conceptual processes. We propose to develop a laboratory course on energy based on Jean Piaget's theory of intellectual development. The laboratory sequence will progress from visual, concrete problem-solving to increasingly abstract and mathematical analyses.

Shrinking energy resources make it imperative that architects be technologists -- that they be able to design efficiently and to incorporate energy conservation intelligently into their building designs.
Being able to analyze the means by which buildings consume energy and to understand how patterns of consumption affect occupant comfort requires a knowledge of the underlying processes of energy production and heat transfer. From our experiences at the Univesity of Washington and from conversations with colleagues across the country, we have come to feel that many architecture students do not adequately understand or know how to apply basic energy principles to the design of buildings. As a result, they often rely on previous solutions or rules-of-thumb that may result in inappropriate design or incorrect application of old solutions to new problems.

As educators, we have been long aware of the need to develop energy-conscious design. An entire issue of the *Journal of Architectural Education* was devoted to this topic several years ago[1]. Since then, there have been numerous attempts to resolve the problem, principally through the addition of more technology courses and the integration of energy issues into the design studio. Many of these courses have themselves emphasized rules-of-thumb and design guidelines. We feel that these steps are not adequate because they do not attack the fundamental problem. The core of the problem is that students do not understand basic concepts of energy production. Without this conceptual foundation, they cannot adequately analyze building problems and devise solutions. Guidelines are most beneficial if one knows how to intelligently use them. They are *guides* to thinking, not the end product itself.

We propose that programs of change must begin with a consideration of the cognitive abilities that architectual students bring with them to the study of design. We suggest that the very attributes that contribute to creativity and success in the design studio make it difficult for students to master the frequently abstract technological material presented in courses on energy. But in making this suggestion, we are not pessimistic of the possibility for change. Mastering abstract concepts of energy production and heat transfer may be successfully completed by architecture students if energy courses are taught in a way that takes advantage of their cognitive capacities and builds on them.

Architectural Design
The traditional architectural design process involves the synthesis of a complex array of requirements and constraints, including cultural traditions, specific community needs, zoning and building regulations, financial concerns and environmental considerations. The synthesis of these problems has been and continues to be dealt with largely in an intuitive manner based on aesthetic preferences coupled with general rules-of-thumb.

In this traditional milieu, little attention has been paid until recently to energy-related constraints. However, shrinking energy resources and the need to maximize energy conservation mandates a design based on scientific analysis of the underlying principles of energy use. This leads to a host of new problem areas ane new ways of dealing with them: thermal performance of materials, the impact of climatic conditions on design, and occupant thermal comfort. Much of this analysis takes the form of mathematically-expressed relationships and considerations of cost effectiveness trade-offs between alternative design strategies.

The design process, as well as much other course work in architecture, emphasizes a visual and spatial approach. Porter[2] outlines the design decision-making process in the following way. First, the imagination triggers a mental image of a possible solution. This solution is dimensionless and vague, but it allows alternatives to be sorted out. When a reasonable solution is conjured up in the mind's eye, it is subjected to continued analysis through its externalization and translation into a more concrete two-dimensional form. The form first appears as an "embryonic ideogram" -- in other words, doodles and bubble diagrams. As these sketches are tried and sequentially discarded, one will finally be chose for more complete development.

This visual process enables the mind to become a three-dimensional workshop in which many solutions can be tried before anything is committed to paper. Once a design begins to form on paper, imagery can still play an important role in developing a cognitive concept of what the building would be like, and how the occupant would use it, if it were transformed into three dimensions.

Visual Strategies and Abstract Thought

We suggest that this reliance on a visual mode of thinking is not appropriate to the analysis and solution of energy problems that are often characterized by abstract, mathematically-expressed relationships as well as by other non-visual processes such as cost-benefit analysis and climatic issues. Thus not only is the content of energy courses new, but the predominant mode of thinking is also different.

According to Jean Piaget[3], whose theories of cognitive development have had an enormous impact on how we think about intellectual growth, learning is facilitated when an individual is presented with a "moderately novel" experience that bears some relevance to what is already known. If the experience is too novel, the person will have no cognitive preparation for it. As a result, one of two things may happen. First, the experience may be transformed in a manner that is consistent with the person's present cognitive state. As a result, he or she does not learn what is required. The second consequence of being presented with an experience that is too novel is that the student may learn a very specific response that has no generalizability and which is forgotten soon after the educational encounter.
Thus an important concept in cognitive growth is "readiness." Piaget proposed that learning best occurs when a student is cognitively ready to understand the material and to integrate it into his or her way of thinking. This readiness occurs in steps, with each new bit of knowledge laying the groundwork for understanding the next.

We propose that the fundamental problem faced by architecture students in energy courses is that they are not cognitively "ready" for the course material. As a result, they often learn how to manipulate mathematical expressions, but they do not understand the concepts behind the expressions. Subsequently, they do not use mathematics as a tool; they use it instead as a crutch. They find it difficult to generalize to new situations and problems because they have only an incomplete understanding of the basic principles of energy production and heat transfer.

Before students can utilize mathematica expressions as an analytical tool, they must thoroughly understand basic thermal processes involved. We suggest that architecture students can best develop the abstract, mathematically-oriented abilities required for energy analysis if the courses were taught in a manner that is consistent with the developmental sequence of intellectual growth put forth by Piaget. The Piagetian approach capitalizes on the concept of readiness; a student is presented with material that is consistent with his or her current thinking abilities. The learner proceeds in a systematic fashion from concrete, visual experience to abstract thinking, using direct experience as a way of learning the qualitative properties of objects and relationships between things. This qualitative understanding forms the basis for quantitative, conceptually based intellectual processes that are characteristic of scientific and mathematical analysis. The usual mode of teaching energy courses is to introduce mathematical relationships from the outset as a way of describing how buildings gain and lose heat. But students often do not grasp the underlying logic behind the development of the mathematical equations themselves; thus, they may become adapt at plugging in values, but they don't know why they are doing it.

It has long been assumed that college students' thinking is at what Piaget calls the "formal operational" stage; that is, that college students are capable of applying abstract, logical reasoning strategies to any and all materials that require this approach. However, recent research indicates otherwise. A very large proportion of college students either are not capable of applying or choose not to apply such reasoning strategies, especially when confronted with new, unfamiliar material[4]. Psychologists and educators working in this area have come to the conclusion that when students have difficulty in dealing with unfamiliar material requiring formal operational thought, courses should be designed in a way that leads them through the stages of cognitive growth within the particular subject being studied[5]. Rather than assuming the student will generalize from other experiences and apply logical reasoning strategies to the new material, courses should be designed to insure both the development of logical reasoning strategies and subsequent application to the newly introduced material. Architecture students are capable of abstract reasoning. The problem they face in energy courses is that the material covered is not "moderately novel", but rather is extremely different from their usual courses. Thus, they need to proceed through the developmental stages from the visual and concrete to the abstract level within the course itself.

Energy Courses: from the Concrete to the Abstract

If architecture students solve problems in a highly visual way, then course materials should initially be presented in a concrete, visual manner so that students can form the basis for understanding the abstract concepts that underlie much of the knowledge they need to gain from the course. At the University of Washington, we have put together an interdisciplinary team of architects and psychologists to design a course on energy use based on a realistic understanding of architectural students' cognitive capabilities.
Logical reasoning strategies will be initially developed through exploration and manipulation of concrete objects. Through this continued and varied manipulation, the logical reasoning strategies become abstracted from the concrete molecules themselves and form the basis for what we term abstract thinking.

The course we are developing will be taught in a laboratory-discussion format. The initial learning experiences will involve exploration of concrete materials pertinent to the scientific concept to be taught. This initial interaction with the materials before teacher demands are introduced allows the student to assimilate the materials on his or her own. This process requires the student to actively think about what is happening and to begin to question why particular events occur as they do. In the usual teaching mode, the instructor provides this information: all the student has to do is passively absorb it -- a process that is highly efficient, if the student is cognitively ready for it.

Following the initial exploration of materials, students will be asked to reflect on and synthesize their findings. The students' experiences are then structured so as to lead to concept formation. It is during this process that students must change their way of thinking and begin to operate at a higher level. In order to fully develop a concept, practice with different materials and new situations will occur. From such practice comes the ability to abstract the concept and apply it in new situations. To facilitate such abstraction, students again reflect on and synthesize the entire sequence, with emphasis on moving from the concrete to the abstract.

The laboratory sequence will begin with simple experiments that are designed to give students an understanding of the variability of thermal performance of building materials. This is a *qualitative* stage that is designed to let them discover, on their own, the salient features of materials and to begin to understand the regularities as well as covariations among objects and events. After an initial period of exploration, students will work in small groups to synthesize their findings and begin to formulate hypotheses about the salient features of the material and the process being studied.

For instance, in a laboratory on conductive heat transfer, students will receive containers that vary along several dimensions. The containers will be filled with hot water and students would be asked to decide what factors most affect differences in water temperature after some time has lapsed. Following an initial exploration phase, students will work in groups to synthesize their findings and to formulate hypotheses that they can test in the subsequent laboratory sessions.

Through the use of visual, two-dimensional methods the student will begin to develop systematic ways of analyzing several events simultaneously. Some of the outcomes we would expect by the end of this laboratory phase is for students to be able to determine the dimensions that are important in heat conductance; to be able to manipulate the multiple variables in a systematic manner (for instance to find two containers that are alike on all dimensions except thickness); and to determine which variables are more important than others.

After students have made some simple hypotheses about the dimensions that affect heat conductivity, they will be asked to devise experiments that will allow them to systematically control all other variables while they test their hypothesis. This process is the heart of scientific investigation, and its mastery is crucial to the understanding of basic principles of energy conservation. Activities at this point will be moderately structured to help students develop these capabilities.

In summary, this phase of the laboratory sequence will include a focus on: (1) identification of the variables that are important in conductive heat transfer; (2) identification of the values of each of the variables in a qualitative sense; (3) systematic control of the variables; (4) formulation of objective hypotheses; and (5) development of methods to test these hypotheses.

In the *quantitative* phase of the laboratory experience students will test and measure the impact of the variables isolated in the qualitative phase. Abstract processes of energy production and heat transfer can best be internalized by the student who has mastered an intuitive understanding of the elements involved and who has begun to think systematically about them. This knowledge is based on a thorough qualitative understanding of the process.
This second phase will form the basis from which principles of conductive heat transfer can be abstracted. This involves the transition from the concrete to the abstract, by first being able to symbolize specific concrete experiences.

Students will work through a series of activities structured to enable them to quantify the effect of each identified factor as well as the combined effects of selected factors simultaneously. In order to facilitate their ability to generalize, students will be given a new set of containers that vary on the same dimensions as the previous ones, but by different values. Work will initially focus on measuring the effect of each variable alone, and will progress to the analysis of each variable relative to others. The goal is to get students to move from an analysis based on the qualitative ranking of materials to a precise measurement of the effectiveness of various materials and how their heat conducting properties are affected by other variables.

At this point, we would like students to be able to predict how much the temperature will change when, for instance, material is increased or decreased in thickness, when a new material is substituted, or when two materials are used simultaneously.
Only when students have reached this stage should mathematically expressed relationships be introduced. At this point, they will better understand what principles are involved and how these relate to one another in a concrete sense. Ideally, we would like them to be able to derive, at least in an approximate sense, the equations that are used to model conductive heat transfer. Mathematical expressions can then be seen as a short-cut for transmitting information and analyzing relationships between several variables simultaneously.

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SESSION 18: PUBLIC ENERGY EDUCATION PROGRAM — DEVELOPMENT

18.1

TECHNOLOGY TRANSFER TO THE HOUSEHOLD: THE CASE OF AN ENERGY CONSERVING INNOVATION

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Abstract
As energy prices skyrocket and supplies dwindle, conservation of energy has become paramount. Yet many consumers are reluctant to purchase energy saving devices for household use. There is a multiplicity of reasons retarding consumer adoption of energy saving products such as ignorance, initial cost, apprehension and negative word-of-mouth. Boulding[5] states "the long run effects (of the energy crisis) depend both on the changes in the technology of supply and on what might be called the 'technology of demand', the adaptation of preferences and life styles to changing price and income structures." Hence, it is important to understand the mentality of consumers who do adopt energy saving products. The objective of this study is to examine via diffusion analysis characteristics of individuals who purchased a thermally actuated vent damper for their gas furnace. The vent damper, produced by American Metals Company, costs approximately $70.00. $15 to $30 fee is charged for installation.

Background
The reasons American consumers are sluggish to adopt energy conservation measures is not clear. This reluctance is in great contrast to the Germans who readily embrace methods to reduce home energy use including point-of-use water heaters, heating coils in washing machines, gas ranges without pilot lights and a host of other practices[3]. Moreover, Milstein[18] indicates that the energy conserving behaviors of Americans are confined to only a small segment of the population. Nonetheless, an analysis of consumers who adopt energy saving devices can aid in understanding how to reach this segment. Interestingly, there has been a dearth of studies examining consumer reactions to energy products.

A powerful perspective to examine the acceptance by households of these devices is under the rubric of diffusion analysis. Diffusion analysis (also referred to as technology transfer) provides an insightful framework in which to examine the diffusion of an energy-conserving innovation. The concept refers to the acceptance or rejection of a new product by an aggregate of individuals. Therefore, it represents the communications flow concerning an innovation from the producer to the ultimate consumer. Four elements are central to the study of the diffusion process: (1) an innovation (e.g., energy-conserving product such as the vent damper), (2) communicated via certain channels (e.g., formal media versus word-of-mouth), (3) to members of a social system, (i.e., homeowners), (4) who adopt it over a period of time[25]. The theoretical basis for this study was largely derived from the literature on adoption and diffusion. Each of the above elements will be examined in this study.

Research questions
On the basis of the diffusion concept, the following research questions are raised:

(1) What are the demographic and behavioral characteristics of the adopters of the vent damper?
(2) How important are various communication sources to the adopters of the vent damper?
(3) What sources of information are used by adopters of the vent damper in going through the information processing sequence of:
(1) learning, (2) obtaining additional information, and (3) making the final decision to buy?
(4) How do adopters of the vent damper perceive the attributes of this innovation?
(5) Do opinion leaders who purchased the vent damper have different characteristics than non-opinion leaders?

The Study
Approximately 179 individuals who purchased the vent damper for their gas furnace were asked to participate in the research study. A useable sample of 84 individuals was obtained resulting in a 47% response rate. The sample included individuals from the states of Rhode Island, Massachusetts, and Connecticut. The names of the adopters were provided by American Metals Product Company (the manufacturer of the vent damper), The Providence Gas Company, and heating specialists in Rhode Island.[1]

A mail questionnaire was the principal data collection instrument. To add greater validity to the study, reviews of the variables in the research were conducted with a number of individuals including adopters to ensure that the teminology was clear. The final development of the questionnaire was aided by a pretest. Moreover, most of the research instruments were shown to be valid in previous studies.

Table I provides the variables measured and indicates score ranges for the attitudinal variables. The attitudinal variables used a Likert scoring procedure requiring a response from "strongly disagree" to "strongly agree" on a six point scale. The attitudinal variables are discussed in Appendix 1.

Analysis
The demographic findings in Table II provide useful insight about the vent damper. The demographic profile indicates that the majority of the adopters were in a higher socioeconomic position than the general population. For example, almost 60% of the sample had at least some exposure to college or college degrees. Even the occupation distribution reflects than about 50% of the sample had professional or business careers. Moreover, the levels of income and market value of homes were higher than the general population; 41% had incomes of at least $25,000 while 35% had home values of at least $80,000. Most importantly, 50% of the adopters were at least 60 years old.

Given that the vent damper is a relatively new product to homeowners, this demographic composition might be expected. Typically, the very early adopters of any innovation tend to have a higher socioeconomic background. However, since the vent damper has been available for over two years, one would expect a lower socioeconomic profile. One could conclude that only higher socioeconomic groups are likely to be interested in adopting energy related products. Perhaps, higher education and income provide the impetus for interest in energy saving devices. Bellur and Gnauck[4] found similar results in that households with high education levels were more aware of conservation methods.

The other variables deserve some mention. The annual gas bill for heating was less than $1,000 for 64% of the sample. Interestingly, 42% indicated that they were completely uncertain about the expected savings from the vent damper while 27% expected to save between $51 and $100.

The behavioral variables examined also reflect some pattern. Only 29% could be classified as opinion leaders. This percentage parallels the proportion of opinion leaders found in studies on other products. Inspection of the remaining behavioral variables indicate that 81% were not venturesome in home improvement energy products. This finding suggests that the majority of the adopters were not wiling to take risks in adoption of new energy products.

To add further insight to this notion, Table III shows the perceptions of adopters regarding the attributes of the vent damper. In the main, the adopters agreed that the vent damper has a relative advantage; was compatible with their desires to save energy; was not complex to understand; and presented no safety or economic risks. Hence, the adopters perceived the vent damper as possessing no negative characteristics; therefore, venturesome was not needed in buying the product. On Table II it is clear that 75% of the adopter have strong home energy improvement interest. Moreover, 74% reflected that they had high self-confidence.

Importance of Communication Source

Table IV presents the results in examining the importance of a variety of communication sources. Table V compresses the information shown in Table IV by providing a graphical view of the means for each communication source. In light of these tables, the adopters viewed magazine and newspaper publicity as being of moderate importance while radio and TV reflected little importance. For the advertisements category, however, the newspaper clearly provided greater importance than either radio, TV or direct mail, which possessed little importance as sources to learn about energy saving products.

The word-of-mouth sources on Table IV indicate that these channels of communciation were of strong importance to the adopters. This was expected since word-of-mouth sources often seem credible and easier to understand than the formal media. Displays and signs had very little significance to the adopters.

Finally, of the two personal exposure sources, the heating expert commanded the greatest importance of all the sources in the tables. An explanation for this finding is that the adopters have great trust in heating experts and rely upon their judgement in learning about home energy products. Hence, this source many serve as a valuable vehicle in the dissemination of knowledge about energy saving home products.

Information Processing Stages

Table VI presents the findings from analyzing the sources of information the adopters used in each of the three stages of information processing. Stage 1 illustrates the sources which introduced the vent damper to the adopter. It is clear that publicity and advertisements are far less instrumental in making the adopter aware of the vent damper than personal influences. The personal contacts which are typically informal accounted for 64% of the sources used to learn about the vent damper. The newspaper, however, was an important publicity source (18%) as well as an advertisement source (11%). Normally, the mass media plays an important function in the first stage of the adoption process in terms of conveying information.

Stage 2, reflecting where the adopter acquired additional information after learning about the vent damper, also reveals noteworthy findings. Publicity and advertisement sources decline dramatically to 8% and 8% respectively as sources used for additional information. In great contrast, personal influences accounted for 79% of the sources used in this stage. It is clear that after the adopter learned about the vent damper, his next step was communicating with personal sources to better understand the vent damper as a potential energy saving product. It is also instructive to note that the gas/fuel representative (39%) and heating specialists (21%) were used as frequent sources of personal information. Because mass media sources do not provide the personal interaction afforded by personal sources, the adopters turned to informal contacts to obtain additional information.

Stage 3, depicts what source helped the adopter make the final decision to buy once enough information has been collected. In this state, publicity and advertisement became unimportant. Instead, personal sources continued to dominate; 71% of the contacts were of a personal nature. In this personal category, the gas/fuel representative remains as an important information source at a 34% frequency. Friends and relatives, too, are important as sources in helping the individual finalize his decision to buy the vent damper. In 27% of the cases, the adopter didn't seek or receive help in making his decision. Apparently, these individuals felt secure or independent enough to proceed without talking to others.

Opinion Leaders

Because opinion leaders often exert significant interpersonal influence, they can be highly instrumental in disseminating knowledge about an innovation such as the vent damper. Table VII provides a test of the means of communication sources to learn about energy saving products for opinion leaders versus non-leaders.

Although most of the tests failed to show a difference between opinion leaders on many of the sources, there were some positive results. For example, opinion leaders viewed newspaper publicity as greater in importance than non-leaders. This was statistically significant at the .01 level. In general, previous studies in other fields have shown that opinion leaders are in greater contact with the media. Moreover, there were significant differences at the .01 level between opinion leaders and non-leaders on the importance of TV and direct mail as communication sources to learn about energy saving products. The opinion leaders viewed these sources as more important.

Another statistically significant relationship occurred for the importance of local experts as word-of-mouth sources and personal exposure to friend's energy related products. Compared to nonleaders, opinion leaders indicated that local experts were less important but seeing a friend's energy related products was more important. On the basis of testing for difference between opinion leaders and non-leaders for the perception of the attributes of the vent damper, there was only one difference; opinion leaders perceived the vent damper as having greater safety risks.

There are correlations for opinion leadership with several other variables. The correlation of .40 (.001 significance) between opinion leadership and venturesome in home improvement suggests that opinion leaders may be venturesome. Hence, opinion leaders seem to enjoy experimenting with new energy saving products, even if they are less well known and not generally excepted by homeowners. Another significant correlation is the association between opinion leadership and home improvement interest. The .50 correlation may imply that opinion leaders are much more vigorous and active in talking with friends about energy home improvement products, looking at the media for these products, and trying to keep their home heating systems as efficient as possible. The lst correlation of .26 between opinion leadership and self-confidence may indicate that opinion leaders are much more confident and secure in their lives. Hence, they are not reluctant to discuss energy products with others.

Implications and Conclusions

The findings have important implications for the understanding of the diffusion of energy related products. The primary purpose of the study was to apply diffusion theory to the vent damper. The study strongly suggests that adopters of the vent damper have a higher socioeconomic background than the general population. Therefore, methods to reach individuals who are in lower socioeconomic groups is needed. The difficulty in marketing this product, however, may be finding the communication vehicles to reach the other market segments. The majority of the adopters were also shown to have self-confidence, a strong interest in home energy products, but not willing to experiment with energy products they are uncertain about.

The analysis of the media viewed as most important indicates that personal or word-of-mouth sources are much more instrumental in promoting awareness about energy related products. Moreover, the information processing sequence examined illustrates that personal sources were the most effective in bringing about awareness of the vent damper, providing additional information, and aiding in the final decision to adopt the vent damper.

Since interpersonal sources seem to be the most effective communication channels, greater emphasis on using these sources to stimulate use of energy related products could accelerate the diffusion process.

In sum, this study has revealed a number of significant findings. Since conservation of energy in the household is necessary, diffusion analysis can assist policy makers and business in fostering acceptance of energy related products. Additional research should be undertaken on individuals who are aware of the vent damper but fail to adopt. Moreoever, analysis of other energy related products would provide support for some of the conclusions developed in this study.

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APPENDIX 1

Opinion Leadership Scale. Opinion leadership refers to the personal influence an individual has over others. This scale was a modification of Roger's self designation scale (25) used by King and Summers (15); Darden and Reynolds (10) and Summers (27). The items were modified to reflect opinion leadership on the vent damper. The scale was chosen because it was more economical and convenient to employ than other measures. Moreover, Reynolds and Darden (22) reported the split-half reliability of this scale to exceed .70. Others have supported the validity of this measure.

Venturesome Scale in Home Improvement. This was a modification of an instrument used by Summers (27). The validity and reliability of the scale was established by others. It is operationally defined in this study as the willingness to take risks in the purchase of new energy products for the home. In essence, it measures an individuals willingness to experiment with the latest energy products for the home.

Energy Home Improvement Scale. This was an adaptation of a scale employed by Reynolds and Darden (22). The scale measures the interest individuals have in improving their home through the use of energy savings products.

Self-Confidence Scale. This scale was used by Reynolds and Darden (22) and Summers (27). It Measures the general self-confidence individuals reflect about their behavior. Self-confidence is considered an important explanatory variable for an individual's behavior in a social context and has been related to opinion leadership.

TABLE I: VARIABLES IN THE STUDY

VARIABLES

I. **Attitudinal Variables**

1. Opinion leadership
2. Venturesome in home improvement
3. Home improvement interest
4. Perceived product attributes
   - Related advantage
   - Compatibility
   - Observability
   - Safety
   - Perceived risk
5. Self confidence

II. **Demographic Characteristics of Purchaser**

6. Age
7. Occupation
8. Education
9. Income
10. Sex

III. **Communication Sources**

11. Importance of infomration sources in learning about energy saving home products
12. Types of media to learn about Vent Damper
13. Media used to obtain additional information about the Vent Damper
14. Media used to make final decision to purchase

TABLE II: DEMOGRAPHIC PROFILE AND RELATED VARIABLES

Age:

25-29 :	3%
30-39 :	20%
40-49 :	6%
50-59 :	21%
60-79 :	50%

Sex:

Male :	84%
Female :	16%

Education:

Less than high school	:	8%
High school graduate	:	33%
Some college	:	21%
College degree	:	22%
Graduate degree	:	12%
Ph.D.	:	4%

Income

Under $10,000	:	8%
$10,000-14,999	:	14%
$15,000-19,999	:	15%
$20,000-24,999	:	22%
$25,000-29,999	:	12%
$30,000 and over	:	29%

Occupation:

Blue collar	:	18%
White collar (clerical)	:	8%
Professional	:	23%
Business Related	:	26%
Retired	:	26%
Mother, housewife	:	5%

Market Value of Home:

Under $40,000	:	10%
40,000-49,999	:	10%
50,000-59,999	:	11%
60,000-69,999	:	20%
70,000-79,999	:	14%
80,000 and over	:	35%

Annual Gas Bill for Heating:

Under $500	:	12%
$500-999	:	52%
$1,000-1,499	:	27%
$1,500-1,999	:	2%
$2,000-2,499	:	5%
$2,500 and over	:	2%

Expected Early Savings from Vent Damper:

Uncertain	:	42%
$10-50	:	11%
$51-100	:	27%
$101-150	:	7%
$151-300	:	13%

Behavioral Variables:

Opinion Leaders	:	29%
Venturesome in Energy Home Improvement	:	19%
Home Energy Improvement Interest	:	75%
Self-Confidence	:	74%

TABLE III: PERCEIVED PRODUCT ATTRIBUTES OF THE VENT DAMPER

Product Attributes and Question to Measure Attribute	(1) % Strongly Disagree	(2) % Disagree	(3) % Slightly Disagree	(4) % Slightly Agree	(5) % Agree	(6) % Strongly Agree	Mean
Relative Advantage The Vent Damper installed in a furnace is superior to a furnace without it.	2	0	1	11	45	41	5.2
Compatibility I am certain the Vent Damper will save energy	3	0	1	16	42	39	5.1
Complexity I fell that the operation of the Vent Damper is difficult to understand.	30	46	16	4	3	1	2.1
Observability There was an opportunity for me to learn about the effectiveness fo this product by personally talking with others.	10	21	12	18	31	10	3.7
Safety Risk I feel there are health risks associated with the Vent Damper.	18	47	17	11	4	3	2.5
Economic Risk There was a risk that the Vent Damper could reduce the efficiency of my furnace.	20	62	14	1	0	3	2.1

TABLE IV: IMPORTANCE OF SOURCES TO LEARN ABOUT ENERGY SAVINGS HOME PRODUCTS

RECENTLY INTRODUCED ON THE MARKET

SOURCE	(1) **Great Importance** %	(2) **Moderate Importance** %	(3) **Little Importance** %	(4) **No Importance** %	**Mean**
Publicity					
Magazine	25	51	12	12	2.12
Newspaper	36	37	15	12	2.04
Radio	14	21	36	29	2.79
T.V.	19	30	32	19	2.50

Advertisements:					
Newspapers	38	34	16	12	2.00
Radio	10	21	38	31	2.90
T.V.	16	25	36	23	2.67
Direct Mail	28	31	16	25	2.40
Personal (Word-of-mouth)					
Saw Friend's Energy Related Product	36	21	4	5	1.45
Heating Expert	70	21	4	5	1.45
Displays					
Store Displays	12	33	23	32	2.76
Outdoor Signs & Billboards	6	19	37	38	3.07

TABLE VI: STAGES OF INFORMATION PROCESSING FOR ADOPTION OF VENT DAMPER

SOURCE %	STAGE 1 a (Learning about Vent Damper %	STAGE 2 b (Additional Information %	STAGE 3 c (Final decision
Publicity			
Magazine	0	5	1
Newspaper	18	3	0
Radio	1	0	0
T.V.	0	0	0
Sub total	19	19	19
Advertisements			
Magazine	1	1	1
Newspaper	11	5	0
Radio	0	0	0
Gas Bill Insert	4	2	0
Sub Total	16	8	1
Personal Sources			
Friend, Relative	8	14	17
Retail Store Employee	0	1	1
Gas/Fuel Representative	46	39	34
Heating Specialist	9	21	17
Energy Auditor	0	0	0
Plumber	1	4	2
Sub Total	64	79	71
Other			
Didn't Seek Help	0	4	27
Don't Remember	1	1	0
Sub Total	1	5	
TOTAL	**100%**	**100%**	**100%**

a Refers to the source where adoper first learned about vent damper.

b Indicates the source where adopter acqired additional information after first learning about the vent damper.

c Refers to the source adopter used to make final decision to buy after accumulating enough information.

TABLE VII: OPINION LEADERS VERSUS NON-LEADERS: T TESTS

Publicity	**Opinion Leaders** (N = 27)	**Non Leaders** (N = 57)	**Significant at .01 Level**
Magazine	2.03	2.20	No
Newspaper	1.82	2.33	**Yes**
Radio	2.70	2.84	No
T.V.	2.40	2.60	No

Advertisements			
Newspaper	1.90	2.10	No
Radio	2.90	2.90	No
T.V.	2.42	2.77	**Yes**
Direct Mail	2.13	2.61	**Yes**
Word of Mouth			
Friends Relatives	1.80	2.12	No
Local "experts"	2.30	1.94	**Yes**
Personal Exposure			
Saw Friend's Energy Related Product	2.09	2.81	**Yes**
Heating Expert	**1.46**	**1.44**	**No**
Displays	**2.66**	**2.84**	**No**
Store Displays	2.66	2.84	No
Outdoor signs	2.90	3.22	No
Product Attributes			
Relative Advantage	5.3	5.05	No
Compatibility	2.03	2.15	No
Observability	3.90	3.50	No
Safety Risk	2.71	2.20	**Yes**
Economic Risk	**2.09**	**2.05**	**No**

18.2

COMMUNITY ENERGY

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ENERGY as a community of public policy issue has emerged as a major thrust in Community and Rural Development (CRD) Cooperative Extension programs. CRD looks beyond individual homes to the impacts of energy on neighborhoods and communities; provides information, education and technical assistance for group decision making.

A review of State Cooperative Extension CRD 1980 Annual Reports indicate major community energy programs in economic development, community facilities and services and capacity building.

In the area of economic development, programs focus on the impacts of energy development and exploration on communities. Extension prepared and presented to local government, citizens and industry, the impacts on housing, agriculture, facilities and services, population, employment, economics and land relative to specific energy situations. Education regarding mineral rights, leasing, land holdings, and easements has assisted with contract negotiations and better relations between local government, landowners and energy companies.

Alcohol fuel programs in many states are a team effort with Extension Economists presenting information of feasibility, costs/benefit relationships, financial alternatives and government assistance, marketing, State and Federal regulations and the effects on rural areas and towns.

Wood for fuel has been a major Cooperative Extension program thrust. CRD has prepared information on wood inventories, economics and management of woodlots and fuelwood marketing. In Florida, two projects propose converting wood waste to ethanol for power generating and manufacturing plant boilers.

Providing educational and technical assistance to small business is a major program thrust in one-third of the States. In Alabama and Texas, efforts are underway to reduce fuel consumption in the seafood industry. Energy management and conservation for resturant, motel and small hotel operators with Chambers of Commerce and the tourist industry are key programs in other states.

States are responding to energy concerns of community facilities and services with programs focusing on management, conservation and alternate sources of energy for public buildings, local government, transportation and housing. The municipal buildings audit program in a six-county area of Massachusetts emphasized low cost, no cost measures which could be performed immediately in 90 buildings, in 70 communities.

Transporation has been identified in 20 percent of the States as a local concern. Programs focus on public and employee transportation; routing and rail concerns. In Wisconsin, 1,500 farmers and 110 business firms have modified their use of energy for transportation at an annual savings of $1,250 each.

Educational opportunities for builders, lenders, realtors, and building supply dealers on energy efficient construction practices for homes, public buildings and small business have been targeted.
The Fort Dodge Iowa Home Builders Association and Cooperative Extension provided training on energy efficiency and energy conservation. A Minesota program emphasized solar energy economics, passive and active solar heating, and financing a solar system.
In Pennsylvania, information on energy conservation as it relates to planning, siting, zoning, and subdivision regulations including utilities and solar access has been presented to planning agencies, commissions and local government.
Of the 54 states and territories, 35 percent report capacity building energy activities focusing on ploicy, community planning and education; and work with community committees, councils and task forces.
North Carolina Extension energy policy audio-visual programs have helped people understand some of the causes of energy shortages and learn ways to conserve and manage energy. They reached about 220,000 citizens in church groups and civic and service clubs.
In many states Extension has initiated or coordinated county/community energy committees with local officials, agency and private sector representatives and citizens. These committees study the energy situation, addressing such question as: how is energy used, who is affected and what effect does this have on the economy?
While all Cooperative Extension program areas—agriculture and natural resources, community and rural development, home economics, and 4-H youth — address energy, this report reflects only the major CRD energy accomplishments in 1980.

It is evident through this project that collaboration on community energy concerns, capabilities are enhanced and new opportunities are created.

18.3

ENERGY, EDUCATION and MARKETING

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Introduction

Depending upon the viewpoint taken, various energy problems become apparent. These emerging problems will, quite clearly, be related to technology, public policy, economy, and international politics, among other areas. Even though these macro and micro environment factors greatly influence the magnitude of energy related problems, at the root of all these lies one basic cause: Need for energy. This may sound like a truism, but it is essential for a proper marketing framework. In today's and most likely tomorrow's societies this need, like many others, will constantly be pushed out of balance creating a satisfaction seeking state in all energy users. In dealing with need satisfaction, especially in the area of shortages, marketing becomes indispensible.

Marketing is nothing new to business firms in the energy industry. Producers of energy, as well as hardware manufacturers and distrubutors use it to accomplish specific objectives. It is, however, new to some other organizations which have come in to existance or prominance as a result of circumstances created by energy shortages. This newness, coupled with misconceptions about marketing usually results in ineffective use of it by organizations who need it most.

Almost every organization, whether they realize it or not, perform marketing in one way or another. However, disorganized or narrow minded applications of marketing are neither desirable nor productive. In order for it to be effective its basic principles should be understood. In an attempt to bring some clarity, the primary purpose of this paper is to briefly outline the marketing process in a proper perspective. A secondary objective is to indicate where marketing fits in the energy field.

The Concept of Marketing

"Marketing is the analysis, planning, implementation, and control of carefully formulated programs designed to bring about voluntary exchanges of values with target markets for the purpose of achieving organizational objectives."[1] A careful study of this definition reveals some key points about marketing.

— Marketing is a process - and a very complex one. It is not advertising or people knocking on the door to peddle products.

— Marketing is goal oriented. As in other managerial processes, all marketing functions are performed towards the accomplishment of some predetermined objectives which may or may not include profits.

— Marketing tries to accomplish its task through voluntary exchanges.

— Marketing deals with different targets through different means.

Overlooking these characteristics will lead to perhaps the most important misconception of marketing that it applies to creating and maintaining a demand for something. This is but only one application of marketing and depending upon the state of demand, various tasks may be assigned to it.

EXHIBIT 1

The Basic Marketing Tasks[2]

Demand State	Marketing Task	Formal Name
Negative demand	Disabuse demand	Conversional marketing
No demand	Create demand	Stimulational marketing
Latent demand	Develop demand	Developmental marketing
Faltering demand	Revitalize demand	Remarketing
Irregular demand	Synchronize demand	Synchromarketing
Full demand	Maintain demand	Maintenance marketing
Overfull demand	Reduce demand	Demarketing
Unwholesome demand	Destroy demand	Countermarketing

Exhibit 1 illustrates that marketing is not limited to the creation of demand. In a broader perspective, one can say that marketing is synonymous with demand management, one phase of which may involve creating demand. Most energy related marketing tasks need not create demand but develop, reduce, or synchronize it.

Marketing Management Process

1. - **Setting Objectives:** Being a managerial and goal seeking process, marketing management starts with setting objectives. Obviously, these marketing objectives need to be within the context of organizational mission and in accordance with the other components of the organization.

2. **Situation Analysis:** Organizations and their environments are dynamic, thus subject to change in time and place. Before proceeding any further, the external environment and internal variables need to be examined. This will establish where the organization currently is and help determine the state of demand requiring demarketing, latent demand needing developmental marketing, or irregular demand calling for synchromarketing. These will all require different approaches to marketing.

3. - **Assessing Opportunities and Threats:** The marketing environment is full of opportunities together with accompanying threats. It is imperative not to be deceived and fall into a trap by only looking at the attractiveness of opportunities. This will surely bring failure, and discourage further use of marketing. Those opportunities that are within the domain of the organization and fall into the framework of previously determined objectives should be indentified. Latent demand for energy education is not an opportunity for a local utility company whereas it is a very attractive one for an educational institution.

Environmental threats, which need to be overcome as part of marketing, may emerge either as directed towards the organization or as obstacles facing objectives. Major oil companies have been experiencing the first kind in the form of public distrust and scepticism, whereas the advocates of energy conservation have been trying to cope with the second kind in the form of consumers' deep rooted attitudes towards energy consumption.

4. - **Market Segmentation and Identifying Target Markets:** Markets are composed of consumers with vastly differing needs. This gives markets their heterogeneous character. The process with which these heterogeneous markets can be divided into more homegeneous smaller subsets is known as market segmentation. This division can be made on a variety of bases, ranging from demographics, user status, psyhographic, to responses to marketing factors. Regardless of the dimensions used to segment the market, as long as it is an appropriate one, segmentation will result in mini-markets containing consumers with similar needs and behaviors in the market. Some or all of the segments will be selected by an organization to be served. Those that are selected constitute the set of target markets.

The underlying reason for market segmentation is not academic hairsplitting. It offers various benefits to marketers. First, it forces marketers to think in terms of consumers and their needs rather than products or services. After all consumers do not buy solar panels, but hot water and comfortable enviroment. Second, it allows the selection of those segments that have the potential of contributing towards the accomplishment of objectives. Third, usually different targets will need different marketing mixes.

5. - **Developing Marketing Mixes:** As stated earlier, marketing is a set of activities aimed at satisfying consumers' needs for the attainment of objectives. The need satisfying aspect of marketing involves creating utilities through a careful blend of four marketing variables. This blend, which is the total marketing offering, contains the controllable variables product, price, distribution, and promotion. There exists an optimum blend of these that will best satisfy the consumer and bring the organization closer to its goal. A proper blend of these variables should take into consideration the needs of the consumer in the selected targets, their attutudes, motives, what they are willing to give up to obtain need satifiers, open communication channnels and the like. Mere communication in the form of advertisements does not constitute a marketing mix as some tend to think.

6. - **Implementation:** In order to produce results (preferably desired ones) marketing plans need to be put into action. Even though plans are developed as a whole, covering longer time spans, implementation follows a time sequence. Therefore, partly due to this fact and partly due to time lag effects of marketing efforts, results may not immediately be seen. Instead the marketer will be faced with minor (or major) obstacles and forced to make tactical manuevers. Some of these obstacles can be anticipated ahead of time and tactical plans can be developed. It is those that can not be seen during the strategic planning state which will demand the most time and attention. No utility company, trying to market the safety of nuclear power plants, could have seen the Three Mile Island incident and be prepared to avert the immense negative effects created by this accident.

7. - **Control:** "Marketing control is the regulating device of a marketing program. Like missile control, it detects each threat to the program's process and indicates necessary adjustments. Long before the ultimate goal of a successful marketing operation is achieved, almost all of the marketing phenomena on which the program was established change. Control is necessary to identify the changes in these factors, to assess the impact of these factors on the program, and to indicate any needed adjustments in strategy."[3]

Clearly, marketing is much more involved than indicated by this simplified structure. However, this brief encounter with a formal view of marketing should help dissipate some of the misconceptions and perhaps arouse some interest in marketing.

Energy-Marketing Interface

"The first oil shock, in late 1973 and early 1974, definitely marked the end of the era of secure and cheap oil"[4] creating a great deal of panic, confusion, and hostility towards oil companies among consumers. In this environment some companies found new marketing opportunities and successfully or unsuccessfully attempted to exploit them. Markets experienced a big splash of energy saving devices, insulating material, solar collectors, and many more. This undoubtedly contributed towards increased confusion and distrust among consumers making marketing more of a necessity.

This necessity has been felt even by the Federal Government which has established a first when "the Senate or House has gone on record in favor of the government buying media - instead of using public service ads - for a national campaign on the energy issue".[5] Government can be influential in marketing in two ways. One as being a marketer of ideas, the other as being one of the factors in the marketing environment of other marketers. Probably the second one is easier to perform by providing incentives to the marketers and consumers. The first one, however, at least from a marketing point of view, is a rather difficult one. This difficulty is also shared by the marketers of energy hardware, oil companies, utilities, conservationist organizations etc. This is in part due to lack of full understanding of marketing by some, and in part due to the intangible nature of most energy marketing situations.

The problems arising from intangibility which are more pronounced in non-business cases can be outlined as follows:[6]

- Intangibility of "products"
- Nonmonetary price of purchase
- Lack of frequency of purchase
- Lack of behavioral reinforces
- Need to market to an entire but heterogeneous market
- Extreme levels of involvement varying from very low to very high.

Overcoming these problems will definitely require more than a cursory understanding of marketing. Studies indicate that the primary reasons for high technology energy companies' failures are market barriers and lack of marketing expertise.[7] Not only is it essential to have qualified marketers but they also need to have a full understanding and appreciation of energy and its related problems. It is this blend that enabled Con Edision in New York to gain sympathy and support from its customers.[8]

One very reasonable way of producing the needed manpower in this area is through education. This becomes more of a necessity after "the emergence of a profession of energy managers - responsible for energy conservation programs - and by the growing importance of these managers in many companies".[9] Not only will this satisfy the need for specialists but it will also emerge as a very attractive marketing opportunity for educational institutions, especially in the era of enrollment crunch that seems to worry all but the mighty institutions. Curiously enough energy and education have a lot in common when it comes to marketing.

Some colleges, such as Providence College, are responding to this need by offering programs in energy management. They are also indirectly contributing to the two step communication process with the society. It is important to realize that "the need for people who can manage technology is just as great as the need for those who can produce and practice it".[10] Such programs will not solve the energy problems. That is quite obvious. However, their contribution to both the solution in the long run, and the management of the problems in the short run, will certainly be most pronounced.

Conclusion

It is not the intention of this author to offer marketing as a panacea to energy problems. However, even the half hearted attempts at using marketing, point at the need for it. Like any tool, it must be fully understood before use. Narrow visions of marketing, limiting it to advertising, will not produce the desired results. There is a need for a new breed of specialists well versed in both technical and managerial skills. Education institutions can fill this gap by offering degree programs leading to much needed people in these areas.

Footnotes

1 Philip Kotler, MARKETING FOR NONPROFIT ORGANIZATIONS (Prentice-Hall, Inc., Englewood Cliffs, N.J. 1975), p. 5.

2 ibid p.80

3 Martin L. Bell, MARKETING CONCEPTS AND STRATEGY, (Houghton Mifflin Co., Boston, 1979), p.465.

4 Robert Stobaugh and Daniel Yergin, ENERGY FUTURE: REPORT OF THE ENERGY PROJECT AT THE HARVARD BUSINESS SCHOOL, (Random House, New York 1979), p.4.

5 Advertising Age, October 22, 1979, p.1.

6 Adapted from: Michael L. Rothschild, "Marketing Communications in Nonbusiness Situations or With It's So Hard to Sell Brotherhood Like Soap", Journal of Marketing, Spring 1979, p.11.

7 Harry M. St. John, "The Energy Market for High-technology Companies", Journal of Marketing, October, 1978, p.47.

8 See: "How A Utility Can Win Friends and Influence Government", Advertising Age, October 29, 1979, p.63.

9 Robert Stobaugh and Daniel Yergin, "The Energy Outlook: Combining the Options", Harvard Business Review, Jan-Feb., 1980, p.69.

10 "Washington's Technology Dilemmas", Great Decisions '79, Foreign Policy Association.

18.4

TEACHING A COURSE ON ENERGY FOR THE GENERAL PUBLIC — A CHALLENGE FOR EDUCATORS

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Abstract

One of the missions of a community college is meeting the general and continuing education needs of the community which it serves. Nowhere has this need been more keenly felt lately than in the area of education pertaining to energy policy and energy production technology. In repsonse to this perceived need this author has endeavored to construct a course based in the Physical Sciences Department which deals with the major issues of the energy situation in which our world finds itself. Of necessity this course must be multidisciplinary and its multidisciplinary nature creates new problems pedagogically for the instructor and for the student alike. Instructors are usually monodisciplinarians and usually are based in restricted discipline departments. This not only circumscribes what has been formally learned by a person teaching a course but also circumscribes what that person is allowed to teach. Therefore a network between departments is needed to supply the expertise and to underscore the complexity of the energy problems we are facing. For the student a multidisciplinary course requires a new way of using the education which they already have and being willing to discuss politics, economics, sociology, history, etc. in the context of a nominal physical science course. This paper presents the content of a course which deals with the energy situation from a multidisciplinary approach and it underscores both the problems and the successes with this approach over the three years which the course has been given.

Text

The course to be described in this paper has been taught for four semesters at Dutchess Community College in Poughkeepsie, N.Y. Each time the class was comprised of twenty-four students with diverse backgrounds and no particular training in the sciences. Roughly two-thirds of the students were taking the course to satisfy a science requirement and one-third were using the course as a general elective or for general interest. Even among those taking the course to satisfy a science requirement there was interest in the social, political, philosophical, economic, and historical as well as scientific aspects of energy. In fact, the multidisciplinary nature attracted these students to take this course to fulfill their science requirement. Therefore the students' expectations and the mandates imposed since the course satisfies a science requirement and is taught in a science department help reinforce the difficulty of teaching about energy which is such a complex topic.

The course is four credits, three credits for lecture and one credit for a two hour laboratory; thus, the format helps define the way in which to satisfy the rigor in the sciences, sufficient to allow the course to satisfy a science requirement, and to provide for breadth in the other disciplines which a thorough discussion of energy requires. The lecture deals almost exclusively with the technical and scientific aspects and the laboratory deals with energy in the context of social science, political science, philosophy, history, economics, etc. Although this structure lends itself to treating the subject in a multidisciplinary manner, actually doing this is not so easy.

This paper therefore concentrates on the difficulties of presenting an integrated, multidisciplinary energy course within the context of a physical science course. There are two pimary areas of difficulty. The first area is pedagogical and revolves around making the non-traditional laboratory experience fit naturally with the scientific and technical knowledge dealt with in the lecture. The laboratory experience involved guest lecturers and field trips and coordination of scheduling is often as much a problem as drawing the material presented by the guest lecturers and field trip speakers into the mainstream of the course. Coordination points up the other difficulty which is simply interesting people in participating in the course as guest lecturers and field trip leaders or in convincing other departments that a multidisciplinary approach was valid pedagogically at the introductory level.

Many of the individual difficulties revolve around the structure of traditional education. Students and educators think in terms of monodisciplines and energy is a topic which is not monodisciplinary. Therefore in discussing topics like energy students and educators alike must learn to think in new ways and to resist compartmentalizing what they know. Educators must be willing to learn about new disciplines and to call in experts in other fields to supply depth where needed. This necessitates not only personal willingness to recognize that one does not know everything but also an institutional willingness to train people from one discipline in the intricacies of another. This is vital because the person running the course must be able to communicate with the guest speakers and field trip leaders and the guest speakers should be able to appreciate what is being taught in the lecture portion of the course. Students must also be willing to discuss topics in one course in terms of things learned in other courses. Without fostering this intergration of the students' education, multidisciplinary courses will fail to achieve the synthesis they should.

It is important to note that educators do not in general encourage multidisciplinary approaches to topics; the monodisciplinary structure is often too engrained in an institution and in the educators' backgrounds to foster a multidisciplinary approach. Discussion of non-scientific topics within a science course is often viewed with disdain as being dilitantism or an encroachment on someone else's specialty. Therefore undertaking a multidisciplinary course even as suggested here with a natural division afforded by the laboratory-lecture format, between the scientific and the non-scientific, can be troublesome. Often the educators who speak loudest about encroachment are those who are least willing to participate thus further exasperating the problem of dealing with other departments and presenting the topic of energy from many points of view. Therefore, prior to teaching the course presented here it was necessary to meet extensively with other departments and solicit support both for passing the course in the curriculum committee and for obtaining agreements with individuals to lecture within the course. Also it was necessary to obtain administrative support for both the multidisciplinary concept and for monies for field trips and guest lecturers from other institutions as necessary. Without setting this framework of institutional support and cooperation the course could not have succeeded. Therefore, those who are interested in attempting a course like this should not lose sight of the importance of this time-consuming first step. Students alone cannot make a success of a course like this; it is the interaction of the various people with their various perspectives that makes the course vital.

Once support for the course is obtained then integration of the course itself becomes the prime concern, since without diliberate integration on the part of the person running the course it is nothing more than a group of loosely related lectures, like a collection of essays. This author has found that the best way to achieve integration is to divide the semester as follows: first there is a one week introduction, following that there are three four week sessions covering basic principles, present energy use, and future possibilities, and the last two weeks are concerned with comparing and contrasting various energy alternatives for all points of view.

During the week's introduction all aspects of why energy are important is dealt with so that the student can obtain a perspective from which to approach the course. To that end the laboratory portion of the first week's work is a discussion with the local county planning board to see what kind of energy considerations must be dealt with in a setting close to home.

The first four week section of the course deals with basic principles. Thus in lecture the basic principles of physical science which relate to energy and energy production are discussed. There is no prerequisite of any scientific knowledge so the overview of basic physics, chemistry, and geology is descriptive. While these principles are being presented in the lecture, political scientists, economists, historians, etc. present basic material in their respective disciplines as it relates to energy during the laboratory portion of the course. Integration of all this basic knowledge is difficult to any extensive degree. However, some integration is possible; for instance, integration between thermodynamics and economies or historical development of the use of coal and the scientific interest in efficiency. Wherever integration was possible it was done but the students were also reminded that the first section was establishing the needed background for depth of discussion later. Emphasizing this is important in retaining student interest and in underscoring the need for the background information.

It is important to note that obtaining guest lecturers who understand the mission of the course and who are during the first section willing to provide an overview of their disciplines is often difficult. The tendancy is for the lecturers in this first section to try to attack the broader questions of energy as it relates to their disciplines without setting the stage by describing what their various disciplines entail. Also guest lecturers are often reluctant because it requires extra work to prepare a cogent introduction to their disciplines sufficient to allow students to come to grips with the multidisciplinary nature of the energy situation. Often it is possible to convince colleagues to take on this extra work if one agrees to present material on some aspect of their courses from one's perspective. Reciprocating like this is effective but it can lead to considerable demands on the person doing the reciprocating since one can easily end up with eight or ten guest lecture commitments. Thus managing the guest lecture portion of the course is a major undertaking for the person running the course.

The middle four week section of the course is somewhat easier to manage since it deals with current energy production and consumption. The lecture deals with the technology of energy production and consumption such as the construction of modern electrical generating facilities including hydroelectric, fossil fuel powered, nuclear powered, etc.; the technology of transportation engines, the ways in which energy is used in materials and goods production, etc. Therefore it is easy to add the other dimensions to these topics in the laboratory by visiting electrical generating facilities, the local mass transit authority, heating oil and gasoline distributors, etc.

The third section of the course deals with future energy technology and its implication socially, politically, economically, etc. This is the hardest section to coordinate since the speakers who discuss the various aspects of future technology and energy needs all explore their topics from different perspectives. Therefore the person teaching the course must pay particular attention to the details of the guest speakers' talks so that what the political scientists say about making energy policy inter-relates with what the economists say about paying for the technology and these views must be reconciled with the impact on the social structure. This is difficult to do but when it is accomplished the students are able to understand the interdependence which the course attempts to identity and explain. Also it is important to treat these various aspects with a panel for each discipline's prespective fo the energy question so that the students quickly see that there is not simply one political, economic, or social view as there is also not a single technological path to take.

Finally in the last two weeks the students synthesize what they have studied throughout the semester. This is the most difficult section for the students but it is invaluable in forcing them to grapple with the complex of the energy situation and not simply end the course continuing to listen to others grappling with the problems. The first part of the two weeks both in lecture and laboratory the students undertake minidebates such as coal versus nuclear, coal versus importing oil, growth versus nongrowth, large scale solar versus small scale solar, etc. These debates help the students to focus their attention on the pros and cons of a variety of options. Having looked at various options in groups of two the students are then able to focus on the energy picture as a whole in the final week of the course. The students each develop an energy policy for the local region, the United States, and then the world as a whole.

The students who have taken this course are enthusiastic about the course. At first they are reluctant to grapple with the problem from a multidisciplinary perspective since they are unfamiliar with it but as they learn the basics of the various disciplines involved and as they listen to faculty wrestling with the problems from multidisciplinary prespectives they gain confidence and become increasingly involved in classroom debates. Thus it is possible to have the last two weeks be a particularly meaningful experience. An experience which will hoepfully serve to develop an awareness in the students that will carry over to their lives in general. This of course is an ideal outcome for a general education course.

The challenges that remain for this course are insuring even better coordination with the guest speakers and a continuation of support by outside speakers and field trip leaders. This will require further administrative support as well as faculty enthusiasm. So far the complexity of the energy problems has enticed faculty to become guest speakers to have a chance to present their views and their solutions.

18.5

ENERGY EFFICIENCY BEYOND TECHNOLOGY

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Abstract
Recent research has provided an opportunity to integate three separate sets of data in a way that could transform marketing and educational approaches to popularizing energy conservation. The three research conclusions are as follows:

1. Human behavior factors have as great an influence on energy use as mere technical solutions, or an even greater influence.

2. Certain aspects of low energy behaviors have broad appeal to people caught up in problems stemming from high energy use.

3. There is a broad market base, or consumer preference, for conservation that is not being exploited.

This paper integrates these conclusions and suggests new approaches to the advertising, teaching and further research of energy conservation.

Human Behavior Factors
One error we have made is to believe that the word "energy" did not exist prior to 1807. Although this fallacy has been popularized by experts[1 2], it is refuted by the Oxford etymological dictionary[3]. The year 1807 may have represented a turning point in our understanding of energy by defining it as external to human life. With the new machines and sources of energy of that age, energy began to be more closely defined in its relation to technology, but for hundreds of prior years, the concept of energy was linked more closely with people. As long as we continue to define it as an external and technical quantity, its conservation will seem to be a threat to technically-defined well-being. Recent research, however, has shown that the human-centered factors involved in energy use have extreme importance. Here are some selected examples.

L.G. Speilvogel[4] reports that the energy used by a residential heat pump over a nine year study shows little correlation with variations in the external climate; the cause of the wide fluctuations must relate to human interference in adjusting the controls. He also reports on the three-fold variation in energy consumption in architecturally identical learning centers in Dallas, Texas[5] which had varying mechanical systems but also had varying management. Richard Stein described a study of New York city schools[6] in which a heating energy reduction of 25% was accomplished with "a dependence only on altering the use habits of the occupants and operating personnel". Dr. Robert Socolow coordinated a study of essentially identical townhouses[7] where the "observed variation in energy consumption for space heating...is primarily assignable to the resident rather than to the structural features that persist independent of the resident". Stephen Julias reports on a study of residences in Washington, D.C., Chicago and Tucson[8] in which the "first finding from the regression analyses was that a large variation, as high as 25%, in energy consumption existed between essentially identical housing units in the same neighborhood". In studying two California energy-saving communities, Jan Hamrin found that "people in houses with the greatest technological potential for savings actually made fewer conservation efforts on their own than did people in conventional houses of a comparable natuare"[9]. M. Janice Hogan of the University of Minnesota found behavioral factors to be important in the areas of cooking and hot water use[10]. An analysis of a computerized energy audit program revealed that even "those participants who chose not to take retrofit action, there was less fuel consumption than among the control population who also had taken no retrofit action"[11]. In a study of international residential energy end use, Schipper and Ketoff found variations "too large to be explained only by technology"[12]. A comparison of New Ulm, Minnesota with Mora, Sweden " revealed that Mora uses only 59% as much energy (excluding transportation fuel) as New Ulm for the same number of people and the same standard of living"[13]. Schipper and Lichtenberg found approximately the same statistic[14]. However, a mix of technical and social factors are cited in each of the above international comparisons.

Management consultant Thomas Werner emphasizes "changing people's habits as well as changing equipment and facilities" to reduce energy use[15]. Studies of the influence of human attitudes on energy use in commercial buildings in St. Louis[16] and in Texas[17] further confirm their importance.

In other energy use sectors, the same pattern is discovered. DOE's efforts in conservation in the transportation sector demonstrated the importance of the drivers' attitudes[18], and an analysis of the wide variations in energy used by several cooks in the preparation of identical meals on identical electric ranges shows that "the variation in the energy that the cooks used is so substantial that it outweighs variations likely to be found in the efficiency of the stoves"[19]. Landsberg and Stewart cite the cooking experiement to supplement their finding that "building occupants...can change energy consumption by as much 30% by the way they interact with the building and its systems"[20]. Similar findings can be reviewed in reports by Donovan and Fischer[21] and Arthur Rubin[22].

The conclusion of all these studies is that attitudes and behavior are either as equally important as technical solutions to the problems of high energy use, or even more important.

The "Salable" Aspects of Low Energy Lifestyles
Even though it can be demonstrated that the standard of living is not coincident with high energy consumption[23 24 25] many Americans fear that "saving energy will require cutbacks in standards of living"[26]. On the other hand, there are some who believe that the late 1980's will bring a change for the better[27]. Following accepted guidelines for motivating social progress[28], we, as educators and/or marketers, should look to the aspects of low energy lifestyles which have broad appeal. Although motiviation toward conserving behavior has often been traced to financial judgements[29], some research suggests that there are intrinsic, desirable values involved in low energy lifestyles themselves. Early Cook[30] provides us with an extensive comparison of low and high energy societies which can be summarized by the following:

The comparison points to many features, advantages and benefits which exist in low energy societies. The negative aspects of many low energy societies — illiteracy, starvation and poverty — can be ignored within this paper because they are not necesarily coincident with low energy use in the context of a high energy society which has long solved those problems. There are several approaches which confirm the occurance of these low energy social characteristics when a high energy society uses less energy.

First our history finds tighter family and community structures, respect for the elderly, more agriculture and so on. Television shows like "The Waltons" and popular magazines like "Mother Earth News" are filled with the nostalgia of our past and refer to renewable energy and a closeness to nature. These romantic resurrections are in sharp contrast with modern American living with its mobility, individual productivity, credit finance and processed foods; Vance Packard wrote "A Nation of Strangers" before the energy crunch of 1973. He described six predictable impacts of the modern lifestyle — less concern for the social consequences of one's behavior, tendencies toward extreme privatism or extreme gregariousness, buying temporary and high-turnover items, relative indifference to local values, an uncertain sense of self and a tendency to live for the moment[31]. Some of these same influences are cited as key psychological factors in the personality profiles of assassins[32] and suicide victims[33]. The anxiety of speedy, high energy living is cited in the analysis of troubled and destructive behavior of juveniles[34]. The top selling prescription drugs are almost all related to ulcers and hypertension[35] and non-prescription drugs like the depressants alchohol and marijuana are popular as well. The recent success of the movie "Ordinary People", the growing rate of youth suicide and the increasing drug abuse among the children of the rich received front-page attention from the Wall Street Journal[36]. The obesity and cholesterol problems associated with high energy diets add to the appeal of their low energy, "natural food" counterparts. The low energy past has indeed evolved into a high energy, problem-filled present.

In addition to a historical comparison of values associated with increasing energy use, there is another set of observations of behaviors which occur after such social disruptions such as blackouts, transit strikes or massive snowfalls which further demonstrate the benefits of low energy use. Personal interviews by this writer with dozens of participants in such disasters have shown them to be cast into a low energy state with characteristics similar to those described by Cook. When transportation, media and centrally generated power are cut off, the participants report an increasing reliance on fellow family members, neighbors and rumor — all low energy characteristics. This is usually, but not always, reported as a pleasant experience. One national study of residential energy use in 3200 households revealed that there is a higher than average proportion of elderly people living in low energy households.[38] Again, this coincides with a social characteristic of low energy societies.

Finally, there is a rising popularity of a "new age consciousness" which promotes calm, meditative, close-to-nature states which are popular in low energy societies. For instance, a brief reading of "New Age Magazine" will show the morality, diets, philosophy, agriculture, furniture and clothing promoted in both the feature articles and the advertisements. Some ads publicize weekend retreats which try to eliminate the influence of mass media, drugs, medicine, transportation and diets associated with high energy lifestyles. Throughout the periodical, there is an explicit and coincident push for energy conservation.[39]

The Untapped Market

The third line of research leads to the conclusion that there is a broad market for energy conservation that is yet to be exploited. Recent polls clearly show that over half of the American adult population desire conservation and/or renewable energy in their lives[40]. The telephone hotlines in national energy information centers are very busy. There is a basic logic behind the demand for conservation; high energy prices, inflation and climbing interest rates provoke its popularity. Yet the typically small businesses that serve the market are usually cash-poor and puzzled at a low response for their products and services. Many are unnoticed by the populace because there is no money for advertising. But the market is there; Patricia Weis[41] has summarized two dozen polls, and the Solar Energy Research Institute has done a similarly comprehensive market analysis[42] all of which substantiates the existence of many potential conservation customers.

Sterngold and Kotler suggest a social marketing approach which could be based on the expressed needs of the market[43]. Their program emphasizes a consumer orientation that elicits voluntary behavior through the use of motivational, subjective, symbolic meanings as well as through the presentation of straight-forward information. These subtler motivational forces could be rooted in the positive aspects of low energy behavior and the importance of human attitudes discussed above. In the same fashion that each aspect of marketing a hamburger is dissected, analyzed and colorfully represented, conservation marketers and educators can kindle interest in their product. The following are just a few possible formats which could be used to promote conservation in the mass media:

> testimonials from elderly people, candlelight and firelight parties, social life in vanpools, family togetherness in a power blackout and community conservation projects.

Clearly, any educational approaches should be multidisciplinary. The social and psychological aspects of low energy use are foreign to typically technical approaches. Classroom investigations could include further research into low energy societies, an examination of family life on those snow storm days when everything shuts down, experiencing non-technical and low energy activities (art, meditation, rumor, etc.), interviews with vanpoolers, a critical review of past attempts to promote energy conservation, interviews of the elderly citizens who "remember how it was", and experiements with group activities like camping, which use only renewable energy.

Conclusion

Low energy behaviors have attractive appeal to those who feel trapped in the hustle-bustle of a high energy lifestyle. These positive attributies are found by observing both low energy societies and low energy situations within high energy societies. It is clear that human attitudes play a key role in reducing energy use. Since we must curb our wasteful behaviors because the petroleum resources are dwindling, a fresh marketing and educational approach to a proven market is worthy of a serious effort. This could be a way to make the inevitable possible.

TABLE 1

Social feature	High energy context	Low energy context
Community	Subordinated to State	Strong social unit
Social unit	Productive individual	Family
Social relations	Dircted toward	Directed toward

	individual choice	social efficiency
Time sense	Linear, scheduled	Cyclical, seasonal
Personal skills	Valued by productivity	Valued by social contribution
Sex and fertility	Separated by drugs	Not separated
World outlook	Firm social base	Strongly discouraged
Information transfer	Media and advertising	Rumor
Value of growing older	Age decreases status	Elders respected
Energy source	Fossil, centralized	Local, renewable
Diet	High protein, obese	Low animal, high starch
Art	Representational	Subjective
Sense of place	Roots lacking, high mobility	Widespread
State government influence	Strong	Weak
Economic base	Industrial	Agricultural

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18.6

ENERGY EDUCATION PROGRAMS FOR THE GENERAL PUBLIC

Simon Singh

Introduction
Of the 4 billion on this universe, only 1 billion have a knowledge of reading and writing, and in the developing countries the literacy rate is lower. By Energy people always think of Atomic energy or the Energy from Natural gases and Mineral oils - Petrol, Diesel etc.

The usuage of Petrol and Diesel oil has become more in advanced countries, and the devloping countries follow up by increasing the transportation by road, rail and air. As the demand goes more and more, the price increases and a day will arrive that even at high prices, the commodities will not be available. The increase in price has caused several countries to ration Petrol and Diesel oil to cut short the consumption for balancing the budget.

Consideration of the production and consumption of energy brings to the fore the questions fo purpose, meaning, and ultimate worth. First of all we find that Americans waste as much energy as the oil imported. Energy resources are limited and every energy system causes some environmental damage. Every energy system offers costs and benefits.

In U.S.A. alone energy consumed is 40 times as much as in Tanzania, and 20 times as much as in Zambia. The energy consumed in U.S.A. is roughly twice as much energy per person as Sweden and West Germany where standards of living are similar to Americans.

Should all work be done by energy consuming machines? Should we go on choosing energy intensive appliances and tools such as clothes dryers and Electric shavers? With some manual labour as part of our everyday lives we will use less of the earth's energy and will even find less need to invent ways of getting exercised. What kind of energy systems should our society employ? Centralised energy systems require an improved and hierarchial bureaucracy to run them. Decision making is removed from the people. In Three-mile Island, the breakdown of the nuclear plant and the proposed economic recovery paid for largely by the customers is a good example of bureaucracy.

Small energy producing systems - Solar systems in every house and a windmill in every yard are needed to transfer energy to places which most need it. Small energy systems will serve best.

Nuclear Energy: - is a great concern as what to do with the multiplied tens of nuclear waste. When safér energy materials are available, we should avoid the risk and destructive potential of Nuclear energy.

We should become as informed as possible regarding energy production and use. The issues are important and complex. We should also keep abreast of what is happening in the world especially in developed countries. We have to make choices such as

Nuclear	Vs.	Coal
Private	Vs.	Public Transportation
Raised energy rates	Vs.	Private homes
Production Concerns	Vs.	Environmental impact
Use of renewable resources (such as wood)	Vs.	Non-renewable (oil and uranium)

Drive your car as little as possible. Ride a bike or walk whenever you can. With improved safey measures and bike paths, bike riders in U.S.A. alone can save 55,000 to 77,000 barrels of oil a day. If you drive to work, double up on car-pool, which can save $250 to $1000 a year. Plan the shoppng trips to include a number of stops in a simple outing. By reducing the rate of consumption, we save energy. Practise the three R's -

Re-use
Repair
Re-cycle

Even small matters such as mending socks, patching jeans, refusing unnecessary packings in paper bags and wrapping papers at stores save energy. Use less of aluminium foil and re-use whenever possible. Items packed in bottles and jars can be produced as bottles and jars can be re-used. Use returnable bottles and containers. Avoid disposable paper products such as:

facial tissues
paper napkins
paper plates
paper towels

as paper requires great amount of energy to produce. Get rid of unnecessary electrical appliances - electric tooth-brush, electric can openers etc. Turn off lights when leaving rooms. Television receiver sets and radios when not in use, unplug them.

New Kinds of Systems of Symbiosis and Re-cycling:
1. Waste products from housing estates and rubbish from food processing factories are simply deposited somewhere or burnt. These wastes can be made into compost and which cannot be made into compost can be passed on to the building industry, as building materials, and as cellulose to the paper industry as paper in houselhold waste products alone makes up 30 to 35%. Food processing companies can transfer their rubbish into humus.

2. Acrid smelling feces are diluted and fed into rivers and lies. The pungent dung contaminated with bacteria can be processed by means of bio-chemial methods and used in agriculture as a manure.
3. Purification plants can purify water containing phosphates by using algae.
4. Firms which process wood can turn their waste into compost.
5. Bio-gas can be obtained from organic waste products.
6. Re-cycling factories regain glass, metals, fibres, paper etc.
7. Building rubble can be used to a much greater degree in re-shaping landscapes and in creating artificial hills or by affording protection from noise, in the form of walls, along busy highways.
8. Loss of heat from power plants can be used for agriculture and district heating systems.

In the countries of the European community, 1800 million tons of rubbish are dumped annually. In the Federal Republic of Germany some private firms have developed a rubbish collection and transporting system with inter-changeable containers. More than 300,000 tons of used oil are utilized when district heating methods are produced by waste product combustion.

Alternative sources of Energy:

1. Geothermal Energy: -
Geothermal energy is the hope of the future. In Kjibouti in the horn of Africa, touching the Red Sea, the Lake Assal 153 metres below sea-level has in its zone, Lake Assal - Le Goubet Zone, the Earth's crust not more than five kilometres thick. In November, 1978, a 40 metre high volcano named L'Ardoukoba appeared near Lake Assal. Other active areas outside the Assal region are the Lake Abbe region, near the Dama Ali volcano in Ethiopia, and the Manda Inakir region near Balho. Particularly at Assal, the temperature has to be 250° C, 1000 metres down. There has also to be reservoir, a porous permeable formation that contains fluid to take the heat to the surface. Many geothermal deposits in the world tap saline fluid. In Paris, deep deposits are used for heating. Hot springs, fumeroles are potential sources of geothermal energy.

2. Solar Energy: -
Solar Energy is used in the Third World for several purposes: -
(i) Solar Water Desalination - Solar distillation.
(ii) Solar Refregeration - Air conditioning.
(iii) Solar Energy - Power Generation to generate electricity.
(iv) Solar cooking -
(v) Solar energy for mechanical drive - flour mills and mills an small industries.
(vi) Solar energy for water pumping.
(vii) Solar cells - ELF - Gabon company in Gabon is using solar cells to run Radio - Telephoning system.
(viii) Solar drying.
(ix) Low power solar engines.
(x) T.V. sets, radio and tape recorders run by photo-cells.
(xi) Solar batteries.

3. Wind Energy: -
This energy with modern techniques can be used in favourable areas for water pumping and electricity generation. We can use:
(i) milti-blade windmills.
(iii) wind - generators
(iii) savonius windmills
Wind energy is used almost all over the North African sub-region for pumping water and irrigating land. In some parts of Africa windmills are being constructed of crude materials by local craftsmen. Public interest in wind energy has been rekindled especially in the advanced countries. In U.S.A. since the 1930's, the wind energy is used and since 1950 the energy is used for driving large electric generators. Wind-mills driving generators producing several kilowatts of electricity have supplied power to public electric power grids in Denmark, France and the Federal Republic of Germany.

4. Hydro-Electric Energy: -
Hydro-electric power is utilised in several countries by constructing dams. Africa has one third of the world's exploitable hydro-electric potential but it is under-developed and under-equipped, although very limited, is not being fully utilised.

5. Nuclear Energy: -
All granites contain an average 1 to 3 grams of uranium per ton of ore and the earth's crust contains from 4 to 12 grams of thorium per tonne. In addition there are radioactive substances including pitchblende, uraninite, autonite, torbenite, uranophane fourmarierite and andersinite. Egypt and India have large deposits of thorium resulting from the presence of monazite in the sands of their beaches. Over 20 cities in the world use nuclear energy for lighting the cities' electric lamps. World-wide installed nuclear capacity increased from 3.27 (Gw -e; Gw -1 million Kw) in 1963 to 106.9 in 1978. The cost of nuclear energy is still tolerable, in view of the staggering leap in oil prices.

6. Heat energy from the Sea: -
By using the difference of temperatures between deep waters and surface waters in equatorial and tropical regions mechanical power through a termodynamic cycle is produced. In Belgium a small coastal power-station produces about 20Kw with a 14° C heat difference. The waters off Abidijan are the most favourable for the success of obtaining heat energy from the sea. Japanese experts are making a power-station, the first of its kind in the world - a 100MW commercial floating power station.

7. Wave Energy:
Waves carry energy proportional to the square of the wave height and directly proportional to the interval between waves. The energy available from a plant would be around 12000 to 17,000 Kwh per year per metre of the coast. Wave energy is used for desalination of sea-water for drinking purposes.

8. Energy from Ocean currents: -
The energy is captured in the same ways as wind in windmills. In sites where the current is strong and regular and sheltered from waves, we can obtain the energy from the ocean currents.

9. Tidal Power: -
World-wide, little use has yet been made of tidal energy. Theorotically its potential is enormous, but in practice, it is modest. Only one tidal energy plant exists in the world on the Rance-ria-bar in France.
10. Energy from Bars: -
A bar is an area formed by breakers unfurling on certain coasts, and in particular the West African coasts of Mauritania, Senegal, the Ivory coast, Togo and Benior. This form of energy has not yet been exploited industrially.

11. Biomass Energy: -
Wood still constitutes a very important source of energy. In industrial countries wood has been replaced by coal, oil and natural gas. Unlike most other energy sources in current use, wood is renewable. Comparing with the price of fuel oil, wood could easily replace fuel oil.

12. Methane fermentation (Biological conversion of Solar-energy).
By the fermentation of plant waste in a vacuum, methane (biogas) is obtained. The gas contains 55 to 60% methane and 40 to 45% carbon-dioxide. In India Gobar-gas from cow-dung is obtained. In Ethiopia there are some projects where biogas is obtained from cattle dung. Assuming total recovery from the dung, we can get 210m³ gas per head of cattle per year.

13. Pyrolysis and gasification: -
Heat-treatment of vegetable waste in the absence of air in a reactor, we get volatile products - gas, water, tars, benzoles etc. and solid products - charcoal-like residue (char"). The char can be used as a fuel in the place of fire-wood in traditional uses. Pyrolysis yields pyrolytic oils, which can be used as raw material in chemistry. The pyrogas yielded by pyrolysis has a calorific value between 1000 and 2000 K.Cal/m³. It can be used for

(i) Direct combustion - crop drying.
(ii) Production of Methanol, ammonia.
(iii) use in a specially adapted engine such as the Duvant engine.

Conclusion
All these processes of obtaining energy from alternative sources may help to achieve substantial savings in oil products, natural gas and traditional fuels. Energy costs, particularly of hydrocarbons are rocketing and some developing countries, particularly in Africa 30 to 70% of their export earnings are spent on energy imports, disregarding the indirect effects of the rise in oil prices. Energy consumption is on such a large scale makes us to find all exploitable energy resources.

Except for the oil producing countries, the developing countries, which make up most of the world's population, are suffering, from the increasing cost of modern energy, inflation, the imbalance n the international monetary system etc. Many of the electrical appliances such as the Electric shaver can be made to be operated mechanically like the clock.

18.7

GETTING A CONSENSUS ON ENERGY

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Abstract
Some years ago the management of the Belgium Nuclear Energy Centre decided to create its own channel to the public by editing an informational journal on energy. In a first approach this journal should have treated nuclear energy and the contributions from this institute. One eventually decided to cover the whole energy field and by doing so helping to reach a CONSENSUS on our national energy policy. CONSENSUS also is the name of the journal, a name that sounds and means the same in both the French and Dutch identical versions of the journal.

The journal aims to reach those who make, influence and undergo the national energy policy, viz. government members, mass media and the interested citizen. By selecting authors and subjects we try to cover research and development on important energy vectors, with their promises and drawbacks. An editorial board keeps the scientific and technical level of the articles within the reach of a non-specialized reader.

The impact of this journal is at least variable; the executive level seems to acknowledge the effort, mass media either use the information as a buoy in the ocean of energy rumors or sometimes reproduce articles in sensitive fields as nuclear reactor safety, Pu, CO_2 or radiation doses. The impact on the general public stays to be unknown.

18.8

Teaching Energy, One Approach

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Abstract:
Though energy intrudes into every aspect of our lives, public awareness of the energy situation is quite low. This shouldn't be surprising. The situation is very complex. The information available is very dry. Even an agile mind may fall asleep as it weaves through endless rows and columns of numbers. We, as educators, can do better, We can make the teaching of even the statistically oriented multi-faceted and controversial subject of energy a satisfying experience for both ourselves and our audience. The unique teaching environment of the Ontario Science Centre has to a great extent detemined the approach which I have developed and successfully used. The paper describes my approach which can be characterized by the headings: promote audience participation, use illustrative material, keep it simple, deal with concepts, don't inundate with statistics, show that individuals count and practice what you preach.

18.9

THE "MISSING LINK" IN ENERGY EDUCATION

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Abstract
Educators have responded to the recent need for energy education by developing materials and programs on topics ranging from energy definitions to energy supply. Virtually all of these educational efforts focus on why energy problems exist and to some degree on what mitigating procedures are available to lessen their impact. Very little activity has been put forth to help us *understand* and *shape* the role of energy in our future, and to help us *anticipate* and *adapt* to this energy future. Educators have not prepared students at any level to recognize the forces at work shaping their energy future so that they might both influence this future and prepare for its coming. To date, educators have not adequately addressed the life-style implications and trade-offs of rising energy prices, potential shortfalls and shifts to renewable energy resources.

This paper elaborates on this neglected but important area of energy education. It examines why this area has not been adequately addressed and why this link must be developed. It argues for inclusion of values and ethics in detemining our energy future. This paper also argues for a greater educational thrust into preparing individuals to understand and accept life-style considerations as a means of achieving greater personal freedom and energy independence. It concludes by suggesting a threshold from which this missing educational link can be developed.

SESSION 19: PUBLIC ENERGY EDUCATION PROGRAMS

19.1

THE SCIENCE IN SOCIETY PROJECT

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Abstract
The British Science in Society Project began about four years ago in response to what was seen as the need for socially-relevant resource material for use in school science courses. The result of four years of writing and trials in a wide range of British schools, the course is primarily intended as a general studies and liberal arts course for 16 to 20 year olds. Ultimately, however, it is hoped to provide resource material that could be used at all levels in the secondary school.

The course draws attention to the many ways science and technology interact with society. It seeks to create an awareness that science can be both beneficial and detrimental to society and the environment, and to encourage students to make reasoned judgements which take account of all relevant constraints. To this end a substantial amount of resource material has been produced, including student readers, teachers' background material and decision-making simulation games.

There are nine units, each looking at an important area of interaction between science and society. The presentation will focus particularly on the Energy unit which, by means of readers, decision-making simulations, data exercises, audits, visits and many other paticipatory activities draws students' attention first to their own use and consumption of energy, then to the national and international situation and the question of future energy supplies.

Introduction
Over the last fifteen years school science courses in Britain have undergone dramatic change. The Nuffield approach, itself strongly influenced by American projects like CHEMstudy and PSSC, has had widespread influence and has brought increased emphasis on practical work and the use of concepts to unify factual material. As a result the teaching of science in schools has become more lively and, we hope, more enjoyable for pupils. But most of the progress has been in the teaching of pure science, and in our enthusiasm we have tended to forget the applications of science in the outside world, and to forget the many practical ways in which science will influence the future lives of our pupils, including those who will take the study of science no further, yet will have to live in and come to terms with a world dominated by the effects of science and technology. In a word there has been too little emphasis on the *relevance* of science to everyday life and to society, and science education has become too pure and dry.

Relevance is nothing new in science education. Many essential concepts are already half-formed from everyday experience long before a child learns science at school - for example the concept of irreversible chemical change from early experiences of burning. And good teachers have always made reference to the everyday relevance of science, using for example, railway lines to illustrate expansion and stomach powder to illustrate neutralization of an acid. In this way they have enlivened their teaching by bringing it closer to pupils' own experience. But perhaps reference to the relevance of science has been too infrequent and too often in the manner of an illustrative aside. Furthermore, and this is particularly true of the physical science, the examples chosen have often been drawn from the world of heavy industry and engineering, a world often distant from the pupils' own experience and with which he, and even more so she, does not readily identify. Perhaps it would be better to start with the individual in his home and look for examples close to everday life. And it is not necessary to look far - food, domestic electricity, detergents, medicines - the manifestations of science in the home are endless.

Given all this, the teacher can begin to bring science closer to home and closer to the pupil. Nevertheless, there are still dangers. Most science teachers are specialist scientists, by and large convinced of the benefits science and technology can bring to society, and perhaps rather less aware of their potential drawbacks. We therefore tend to present science in a favourable light, and perhaps to overlook its disadvantages and drawbacks. But when showing the social relevance of science, for example by referring to nuclear power when studying energy the teacher needs to be even-handed and present both sides of this controversial question. This immediately involves him in an activity with which he, as a science teacher, may be unfamiliar, namely open-ended, divergent discussion. We are certainly used to class discussion in our science lessons, but it tends to be a rather covergent activity: the teacher knows the law or generalization at which he wants to arrive, and he can direct the discussion to this end. But the kind of discussion involved when considering socially relevant issues such as, say, the siting of a power station or the question of birth control, is very different. It is more a matter of being a good chairman and ensuring fair play. There is no one 'right' answer, and the discussion may come to no firm conclusion. All this involves the teacher in a situation with which he as a science teacher may be unfamiliar and in which he feels insecure.

If the need for social relevance in science teaching is acknowledged for its value in bringing science closer to everyday life and showing its importance in the world, what should be done? How can science education be made more relevant, paying due regard to the problems and difficulties already mentioned? To include socially relevant material in existing science syllabuses implies a reduction in factual and conceptual material - no bad thing, many educators would say, but a move that is bound to meet with resistance. In any case there is a shortage of suitable resource material, and the prime objective must be to generate such material in the hope that it will gradually become assimilated into science courses, whether mainstream physics, chemistry, biology or intergrated science, or more specialized courses such as those concerning energy which we are considering at this conference. The Science in Society Project, which will now be decribed provides such resources material.

The Science in Society Project
The Science in Society Project seeks to educate pupils to live in a science-dominated society. Perhaps we can also help scientists of the future - only a small proportion of our school pupils - to act more responsibly by being more aware of the potential advantages and disadvantages of any discovery they may make. And we hope we can simply make school science more interesting and enjoyable, by

showing its relevance to everyday life and to society. The Science in Society Project is sponsored by the Association for Science Education, and organised by John Lewis from Malvern, England. It began over four years ago and was published in its final form in January 1981. There were three years' extensive trials of the project material in a wide range of schools and colleges prior to publication. The project has a large team from schools, universities, industry and the professions, who have been involved in writing Student Readers, devising activities and writing Teachers' Guides. At present the course is designed for General Studies with 16-20 year olds, both Arts and Science specialists. (In English schools, most students of this age take a General Studies course of 3-4 periods a week in addition to their main studies.) Ultimately, though, we hope to adapt the course to make it suitable for lower age groups. Our long-term objective is to provide material that will pervade all science teaching in schools.

Aims of the Course

Formalised, the aims of the Science in Society Project can be stated as follows:

1. To understand the nature and limitations of scientific knowledge.
2. To appreciate that the use of scientific knowledge can be both beneficial and detrimental to society and the environment.
3. To appreciate that the Earth's resources are finite.
4. To understand the need for, and to develop the ability to make reasoned decisions which take account of all relevant constraints; and
   to recognize that moral considerations are involved in making decisions.

Content of the Course

If we think of society and its input and output in terms of the diagram below, we can identify certain themes.

Materials	Energy
People	SOCIETY
Desired products	Waste products

The human input and output of society gives us the themses of the Population Unit and the Health and Medicine Unit. The material resources of society are covered in the Mineral Resources, Food and Agriculture, and Resources of Land and Water Units. Energy is vital for the utilisation of these resources and indeed for the entire functioning of society, and thus we have a unit called Energy, described in detail by Paul Jordan in a separate paper. A consideration of the conversion of material to give desired products comes in the Industry in the Economy Unit. Future developments are considered in the unit called Looking into the Future, and a general overview of some of the more philosophical and abstract issues comes in the Facts Unit. We have at all times tried to keep our approach as close as we can to the individual, and wherever possible we start with the human being in his home.

THE HUMAN IN HIS HOME
  Introduction

HIS HEALTH
  Health and Medicine Unit

HIS FOOD
  Food and Agriculture Unit

HIS NEIGHBOURS
  Population Unit

HIS RESOURCES
  Energy, Mineral Resources, Land and Water Units

THE WAY HE USES THESE RESOURCES
  Industry in the Economy Unit

THE QUALITY OF HIS LIFE
  Looking to the Future Unit, Facts Unit

Although the course is arranged in these units, we have tried to make it flexible, and it is for the teacher to decide which units to use. Similarly, there is flexibility within each unit, and it is not necessary to cover all the material included.

How we teach the course

We felt from the beginning that it was just as important to develop teaching strategies as to generate content in a course like this one. Some of the methods and resources used in the Project will now be described.

1. **Publications.** For the purposes of trials we produced a Teachers' Guide for each unit. These guides, together with a general introduction to the course are now published in a single book. This Teachers' Guide outlines the aims and objectives of each Unit and gives suggested teaching strategies and activities. Resources are identified and, where necessary, background information is given. There is also a large number of Student Readers, written by subject experts, concerning different aspects of the course. These are grouped together according to subject and published as booklets of about 64 pages. Each reader comprises 15 to 20 minutes' reading on background information and ideas and might be used in class or to read at home. The Teachers' Guide and Student Readers are published by Heinemann Educational Books, whose address is given at the end of this paper. The total number of readers is about 80, grouped into 12 booklets with the following titles.

Diseases and the Doctor
Population and Health
Medicine and Care
Agriculture
Food
Energy
Mineral Resources
Industry: Men, money and management
Industry: Organisation and obligation
Nature of science
Science and Social Development
Looking into the Future

2. **Decision-making simulation games and other activities.** A major feature of the course is its specially developed decision-making games. By simulating particular situation and enabling students to role-play, these games motivate students and promote their interest and commitment. The games can be bought from the Association for Science Education in the U.K., or from Heinemann Educational Books in the U.S.A.

The list of games is:

Energy Unit	Central Heating Project Power Station Project Alternative Energy Project
Minerals Unit	Buenafortuna Minerals Project
Industry Unit	Public Inquiry Project
Food and Agriculture Unit	Hilltop Project
Health and Medicine Unit	Dental Health Service Project Marimbian Health Service Project

In addition we have developed several other activities to help get the student fully involved. Many of these involve the home: one example is Project Dustbin, in which the student analyses the waste produced in his home during one week, and this leads to an idea of the total quantities of glass, paper, plastic, iron and other materials discarded as waste in the country as a whole.

3. **Discussion.** Much of the course involves discussion of subjects which are matters of opinion. Although it is intended that Science in Society may be taught by both Arts and Science specialists, it is likely that the teacher will most often be a Science specialist, and as already mentioned he may have little experience of conducting the kind of open-ended, divergent discussion which may arise when considering, say, the question of nuclear power. To help teachers with such discussions, the Teachers' Guide contains many *discussion questions* which can be posed to students to help initiate discussion.

4. **Films and T.V.** In Britain there are many excellent films and T.V. programmes that can be used in connection with a course like this - the difficulty is identifying which are most suitable. In the Teachers' Guide we have tried to do this, and have written a number of questions that can be used to promote discussion after viewing the film.

5. **Visiting speakers and visits.** In a course of this kind it is obviously important to bring in the outside world as much as possible. This might be done by inviting visiting speakers - for example, when covering Health and Medicine it is very helpful to get a local doctor to come and speak to the class - or by taking the class on a visit. Visits do not need to be to exotic places, though obviously if we have a power station or steelworks nearby we try to visit it. But a look behind the scenes in a local supermarket is very useful when dealing with Food, and it is easy to arrange a trip to a local quarry or gravel pit when covering Minerals.

Conclusion

The Science in Society Project is a general studies and liberal arts course for 16 to 20 year olds, seeking to give students a better understanding of the role of science in everyday life. The course materials are now published and widely available in Britain and overseas. We do not intend to let things rest, however: clearly in a rapidly changing world our subject matter is constantly changing. We already have a system for updating statistics and data by computer and we have plans for producing audio-visual material relating to our course. Our long-term aim is very ambitious - to give all school pupils an appreciation of the interactions of science and society, and this would involve extending and adapting the course and our philosophy to lower age groups.

Meanwhile, there has been great interest in the Project, both in Britain and overseas and the materials are finding their way into increasing numbers of schools and colleges. Science is not the answer to all our problems, but it is not the cause of them all either. If we can help people to think carefully and rationally about the drawbacks and benefits of science, then we will have achieved something worthwhile.

Addresses

Further details, together with the Teachers' Guide, the Readers and the Decision-making exercises are available from:

Heinemann Educational Books Inc.,
4 Front Street,
Exeter, New Hampshire, U.S.A.

or

The Association for Science Education,
College Lane,
Hatfield,
Hertfordshire AL10 9AA
U.K.

19.2

SCIENCE IN SOCIETY - ENERGY
by
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One of the most important and integral topics in the Science in Society course is the one which deals with energy. Not only does it occur in its own right but also when looking at Food and Agriculture, Minerals and Industry which are just some of the topics covered within the course. The aims of this unit are to give the students a) an appreciation of the independence on energy and how much is needed to support their present standard of living; b) an awareness of how energy consumption per person differs from country to country; c) an opportunity to think about their own environment and to make their own decisions about the use of energy in it; d) an awareness of the amount of energy consumed each year in the world as a whole, and in particular how the rate of consumption is increasing; e) a look at the major sources of energy at present available in Britain, what is involved in making those sources available, and how long they are likely to last; f) an opportunity to consider alternative sources of energy and to assess the contribution which these might make to the future; g) a look at the risks involved in the use of each individual energy source.

These aims ensure that the students not only obtain a picture of their own energy consumption but also gain an awareness of how that fits into the global picture. In order that these aims might be fulfilled the topic is further sub-divided into five sections.

1) Your energy consumption.
2) World energy.
3) Total energy requirement.
4) Energy in the home.
5) Energy sources.

The first section looks at the energy consumption figures for the United Kingdom divided into the various sections of the community. This develops a self-realisation in students of how dependent on energy they are and of the relative quantity used by each sector. In interesting and revealing calculations students obtain different perspectives on the same theme. In the first they find how many slaves would be needed to supply their average daily consumption of energy, and in the second how much they would earn by physical work if they were paid at a rate similar to that paid for electricity. Thus a healthy appreciation is gained for the convenience of our present energy supply and for just what it enables us to do. Two comparisons are now made to bring out the historic perspective and to compare energy consumed per person in different countries across the globe. This engenders lively debate amongst the students and leads into the following section on world energy.

Problems involving the world are often too large to be discussed initially and that is why the course brings students to this point by making them look at their own dependence. Having established this it is possible to compare nations by looking at a graph of gross national product against energy per capita and this again brings out many points for discussion. But none of this is of any value if there is no realisation of the finite nature of the resources of fossil fuels. This is brought out very nicely in Limits to Growth[2] which also deals with the finite nature of many other quantities. The inter-relationship between energy and other quantities emerges from this as well as the importance of looking at the rate of consumption and the rate at which this is increasing. By the end of this students not only realise why there have been 'Oil Crises' in the past but why the 'Crisis' is in fact ongoing. In addition they come to realise this is a problem involving many of the sources of energy currently being used and not one facing oil alone.

It not a problem of finding a replacement for oil but for developing a whole energy strategy. In this way students appreciate that the rate of increase in total energy consumption must be brought down to a much lower level. This leads into the the next question of where is the energy we are consuming being used. For many there is little realisation of the total energy requirement of a product and this is brought out extremely well in Fuel's Paradise[3]. Here an analysis of the total energy requirement to produce a loaf of bread is done to very good effect. The 'Chapman Loaf' shows the 'hidden energy' within the loaf but also brings home the point that more energy has gone into the loaf than can be obtained from eating it!

Whilst the hidden energy is important the real increase in energy consumption over the past 100 years has come in space heating. This accounts for an average thirty nine per cent of the energy consumption of each adult person in the U.K. Energy in the home is therefore important from the two aspects of relative importance and the fact that it affects each one of us individually. To bring home to students where energy is used within their homes and to compare the relative merits of different systems, the central heating of a home is investigated. This is done using one of the Decision Making Games[4] which are an integral part of the course and more will be said about these later. An important concept which many adults do not understand is the efficiency of a heating system and this discussion includes the limitation of the efficiency of a power station. For those who want a more straightforward task there is an energy audit for the home. This then involves the whole family as well as the whole class in debate. So having tracked down where it is going how do we 'save' some of it? A brief analysis of what might be done is then carried through by the students. So having seen how each individual might contribute there s a need to know where we stand in both the local and global picture of enery supply. A nice introduction to this section is the Decision Making Game On Power Station[5]. Having gathered information they have to present their case to an independent chairman. This not only brings about a realisation of what a power station is like but also achieves the aim of teaching them to put forward their side and to listen to the other side in the argument. Having established the concepts there, there is a natural lead in to the 'global problem'. The supply of coal, oil and nuclear energy sources is well documented, together with where those sources reside and who is using them. Finally alternative sources of energy are considered together with their feasibility. Again the use of a decision making game[6] becomes an integral part of the programme. This takes a small island for which the major sources are unviable and considers the alternatives. Solar, wind, tidal, hydroelectric and peat are the sources considered and the students have to investigate their feasibility. Finally they come back together as the town council have to decide upon a rolling programme of energy supply for the next fifty years which will fit a demand curve.

This is of necessity only a brief taster of this part of the course. Certainly for the students that have followed the course the aims have been achieved. Each has that greater awareness of the energy picture for the individual between the two extremes of the home in which they live and the world on which we all depend. They have been involved in decision making to a very wide degree and they are now equipped to enter the outside world and hopefully to make it a better place in which to live.

Footnotes

1 Science in Society, (Heinemann Educational Books, London, 1981)

2 D.H. Meadows, D.L. Meadows, J. Randers, W.W. Behress III. The Limits to Growth, (Pan, London, 1974)

3 Peter Chapman, Fuel's Paradise, (Pelican, London, 79)

4 Central Heating Project (Association for Science Eduction, Hatfield, Herts, London)

5 Power Station Project (Association for Science Education, London)

6 Alternative Energy Project (Association for Science Education)

19.3

COMMUNITY ENERGY EDUCATION: MOTIVATING ENERGY CONSERVING BEHAVIOR THROUGH EDUCATION*

John A. Foss
President, Human and Technical Energy Systems, Inc.

Introduction
Forty self-help, hands-on demonstration weatherization workshops were delivered to lower and lower-middle income citizens in the Boston area during the winter of 1980-1981. The purpose of the effort was to motivate people to reduce their energy consumption through personal, voluntary means. To foster this purpose, a facilitative approach was taken. Workshop participants were provided with information to help them make informed energy-related decisions, and to teach them how to implement practical and available energy savings technologies. A follow-up evaluation indicated that energy savings of at least $57,500 can be attributed to the workshops, which cost $24,000 to deliver.

Emphasis was placed on both technical and behavioral aspects of energy conservation. This is important for several reasons. First, the Princeton studies (Sokolow, 1978) had indicated that even with thermostat settings held constant, about 50% of home energy use might be attributed to behavioral factors, i.e. the manner in which a homestead is operated. Second, many of the most cost-effective energy saving techniques (e.g. turning off lights, or closing shades at night) require heightened awareness of the status of household systems, as well as changes in day-to-day operations. Finally, we recognized that changes in attitudes and behavior could lead to perspectives which could lead participants to initiate energy saving measures for months or years after their involvement with the workshops.

Workshop design
Since the purpose of the program was to motivate people to conserve energy, the workshop design was based on motivational psychology (Foss, 1979/80). Four elements of the design are presented as examples of what is required to optimize the success of this educational approach to energy conservation.

The workshop curriculum had to provide participants with specific *actions* that they could perform to conserve their energy and money. These actions had to be affordable to people with limited financial resources. These actions also had to be done by the people themselves. Thus, much of the curriculum consisted of low-cost/no-cost measures which the participants could implement themselves.

The presentations also had to provide participants with a sense of *hope*. Were participants to come to believe that they could truly change their energy situation for the better, then they might do something about it. Therefore, we made the benefits and possibilities of energy conservation very clear. One of our flip chart posters claimed: "40% to 70% of residential energy is WASTED." This might sound like an exaggeration, but in fact it is trivial to save 50% of the energy consumed in most homes. In fact, participants who let us into their homes for follow-up energy audits had achieved an average of a 44% reduction in their heating bills alone, after attending our workshops.

If we were to motivate people to act, we also had to help them to make the shift from seeing themselves as victims of the energy crunch to seeing themselves as origins who were capable of taking on this new challenge. Instead of being miserable and helpless in the face of rising energy costs, and the financial demands of expensive improvements, they needed to adopt a problem solving attitude, to make the implicit yet heartfelt commitment to perform whatever effective actions were available. We fostered this attitude by centering the workshops around the participants in a passive role; we facilitated and drew them out. We wanted them to ask their most challenging questions, so that they could work with us to move beyond their difficulties. We also wanted them to share their solutions with each other, so they would understand that they could generate solutions to many of their problems.

Finally, we planned with them. We wanted each person to leave the workshop with one (or a few) very specific next steps that were right for them in their situation. By the end of the workshop, each participant had been introduced to a large number of alternatives. This could be confusing, and certainly would not motivate people. Thus, it was important to narrow the many possibilities to a small number of concrete goals which could be implemented quickly and with confidence. The concreteness was important, in part because many participants were in Piagetian Stage 4 (concrete operations). The immediate implementation was important, because the small successes would serve as reinforcers for future successes, and would allevite enough financial burden so that future steps would be affordable.

Workshop features
There were a number of innovative features to the workshops. These were required by the design quidelines, and the effective completion of the goals. These features ranged from content (e.g. the use of the same materials people might use to weatherize their homes) to process (e.g. multiple process format options) to the performance of an evaluation. Seven features are presented below.

1. Creation of attractive materials. The multi-color flipchart attracted participants' attention, highlighted the major points of the verbal presentations, and seved as prompting cards for the workshop leaders. The *Women's Energy Tool Kit* had very nice graphics, and was beautifully printed, so that participants seemed to feel that they had really been given something when they received it. It provided details for do-it-yourself energy savings projects that we could not provide with our limited workshop time.

2. Use of existing community infrastructure. Workshops were offered in collaboration with community organizations which already had strong ties with the neighborhoods. This sped up our outreach and publicity efforts. It also made follow-up support more feasible, since the existing organizations continued their presence long after our project was completed.

3. Training of workshop trainers. We trained about fifteen workshop leaders to provide workshops. This was very important, in particular because it made possible the continued support of people who had attended workshops. We found that people would have follow-up questions when they implemented some of the more difficult energy conservation options, so that follow-up advice was very important.

4. An especially matched and sincere team of program personnel, personally knowledgeable, genuinely and personally committed to wise energy practices in their own lives. These organizers and workshop leaders were able to share from their personal experiences about energy conservation and energy saving behavior. This made presentations vital rather than abstract and intellectural. This in turn made for increased impact on the participants. (We should emphasize that such sincere personnel are not a major challenge to find during a pilot program. However, when a program requires 200 to 500 people rather than 15 to 20, it becomes necessary to pay close attention to selection of appropriate personnel.)

5. Client-centered curriculum and process. The actual offerings during a given workshop were tailored to the needs of the participants. The prepared curriculum was large enough so that major parts could be eliminated if they were not needed during a particular workshop. In addition, trainers were generally working with energy savings in their personal lives, so that they could embellish the curriculum when needed. Further, when possible, the presentation style was adapted to the requirements of the community. If a community was accustomed to the lecture format, then they were provided more with a lecture. If they were accustomed to a participative format, then greater emphais was placed upon their doing hands-on activities and sharing their experienes with each other.

6. Publicity. Each workshop was sponsored by a local community organization which led an extensive publicity campaign. Word-of-mouth, community newspapers, and flyers were among the effective publicity channels used.

7. Performance of an evaluation. The project team performed an evaluation of the effectiveness of the project, in spite of the low emphasis placed on evalution in the RFP and contract. We regarded the evaluation as a very important means for determining the effects of the project, and for discovering how we could have done it better. The evaluation helped us to see clearly what we had accomplished.

Result
The workshops were attended by 488 people. Of these 129 registered before or during the workshops. Follow-up energy audits were offered to participants to provide advice and to evaluate the effectiveness of the measures the participants had implemented. Twenty-six people requested these audits.

Energy savings achieved by the people indicted that 84% of the savings they had achieved were the result of low-cost/ no-cost measures which participants would understand and/or implement themselves. These measures included thermostat setbacks, infiltration reductions, and behavioral changes. Forty percent of the total savings were due to thermostat setbacks, the largest single contributor to energy savings (discussed separately in "Pathways to the Cooler Life,". Infiltrations reductions accounted for almost 28% of the total energy savings. In some cases these improvements were permanent, although in many cases the savings were achieved through such means as stuffing newspapers under ill-fitting doors.

The house audits indicated that many behavioral changes were made voluntarily. Over half the respondents reported instituting winter retreat zoning — not surprising in light of the reduced thermostat settings. Four out of five reported use of reduced wattage lighting, or increased concern for turning off lights and appliances. Almost one third reported shifting toward more energy-efficient cooking techniques. These are self-report figures, and are therefore not to be regarded as highly reliable. Thus, they are not included in the estimate of energy saved as a result of the workshops. However, they can be taken to indicate a degree of attitude change which should yield long-term energy conserving efforts.

Energy saved in the form of oil and natural gas for heating the 26 residences amounted to 2.3×10^9 Btu annually. This is an average of 44% saved relative to usage in the previous year. The savings ranged from 0% to 83% in individual homes. Some of the data indicates that the application of measures introduced during the workshops (such as winter retreat zoning and thermostat setbacks) were responsible for some of the savings. The origin of other measures implemented (such as ceiling insulation) is rather more ambiguous. We are attributing only fifty percent of the savings in the homes we audited to the impact of the workshops. This may mean that our estimates of savings are on the conservative side, as they attribute a 22% energy use reduction to miscellaneous factors, and this is much greater than the 7% reduction in residential gas use measured by Boston Gas during the year ending March, 1981. If in addition, one assumes that fuel costs $1 per Therm, then the lower limit for savings directly identified by audit would be $23,500 per year. This is slightly less than the cost of the project.

An estimate of average savings achieved in residences that were not audited may be obtained by assuming a much lower rate of savings than in homes whose owners were willing to subject their homes to inspection. It can be assumed that such residents reduced their energy bills by only 4.4% (above a base of 7%) instead of 22% as a result of the workshops. With such numbers the yearly savings for all participants are estimated at 57,500 Therms, worth $57,500.

Discussion

The results of the evaluation indicate that motivating energy conserving behavior is not only cost effective, but also may be one of the most cost-effective ways to foster energy usage reductions. A conservative estimate of the simple payback time for the workshops is 1 year. A more reasonable, yet still conservative estimate of the simple payback time is somewhat less than 6 months. This contrasts with typical payback times of one to two years for the most desirable technical options for large buildings fostered by more technically oriented programs.

A secondary benefit of the workshops is believed to be increased flexibility on the part of participants, and a more positive bent in their feelings toward government. The Emergency Building Temperature Restrictions and cynicism about the source of the energy crunch have undermined much of the goodwill many lower income citizens may have had toward government. It is believed that the facilitative approach used in the present workshops counter this orientation by motivating people rather than pushing them. Thus, instead of asserting their selfhood by resisting authoritarian initiatives, citizens do so by accomplishing tasks which benefit both themselves and their nation.

Two matters must be emphasized as recommendations for future implementations of this approach to energy conservation. If a larger scale project is to be implemented, it will be very important to select personnel carefully, so that the interpersonal factors can foster the continued success of the project. In addition, evaluation must be given greater emphasis. Formative and summative evaluation is the means by which learning is made possible in such projects. It is the means by which a project can be directed toward success rather than an ambiguous future. Rigorous experimental, qualitative, and quasi-experimental research designs should be funded in future evaluations.

It is because the evaluation for the present work was a postaudit without control that we have biased our savings estimates on the conservation side. Even so the workshop approach to fostering energy conservation would have a very high impact if expanded. If one third of New England homesteads were to reduce their energy consumption by an average of 15% (not an unreasonable figure in light of the present work) then over 300 million gallons equivalent on No. 2 oil would be saved each year. This amounts to more than 20,000 Bbls. of oil per day. The savings would be even greater if the workshops succeeded in inducing origin behavior. In this case the annual percentage energy use reduction would increase from one year to the next. Thus, if the 15% reduction were to increase to 30% for the average homestead during some year after the workshops, the savings attributable to the workshop would double.

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Socolow, R. *Saving energy in the home.* Cambridge: Ballinger, 1978.

The self-help weatherization workshops referred to in this work were funded by the Department of Energy and the Massachusetts Executive Office for Energy Resoruces. They were implemented by J.A. Foss and H.P. Mahon during winter 1980-1981, when both were on the faculty of the Physics Department at the University of Massachusetts/Boston, Harbor Campus.

Appendix: Question and Answers

Q: You seem to have a really good program here, but not all programs are very good. What makes the difference between programs that are funded, and those that are not?

A: That's a very political question. The answer is that we have to learn to use real discernment and judgement. For example, educational programs such as the one we did have recently been cut by the government. This reflects the idea that it might be a "social program." In fact, I don't think such programs are "social." They are very much in the national interest, even though they may foster a small amount fo social change. I think you will be seeing the government shifting its ground about conservation during the upcoming few months. In addition, the Department of Energy has had a technological bias for years. This program is one of the first legitimate educational programs they have funded,and this reflects a growing understanding on their part that "technical fixes" are not the only way, maybe not even the best way, to foster a more self-reliant society. But let me grind my axe. I think that within any guidelines or ideologies, you are going to see some programs that work, and some that don't. There is no way to write a guideline that will discern. *People* have to make the judgements, and they have to work hard to do it well. They have to work their way beyond their limitations, and the limitations, of the conventions in their milieu. If budget cuts are required, it becomes a question of throwing out the bathwater, but not the babies. If you have discernment, you can help a great deal by contacting your congressman.

Q: How do you make judgements about which programs work?

A: You have to have evaluation. This has been almost completely ignored by DOE, which as been staffed almost completely by technicians. (I know of only two social scientists who have ever been in DOE, and both of them had left by summer, 1981.) This is very unfortunate, because very few technicians understand education or social science. If you do an elementary particle research experiment, your evaluation goes on during the process of the experiment. The high cost of the experiment is partly due to this formative evaluation that is going on. Once you get your result, you don't need any summative evaluation, unless maybe GAO comes in for an audit and says that you could have done the work for $100,000 less. The situation is very different with education and social science interventions. Once you have started a program, it is difficult or impossible to stop it to think about your results, as is common in physics research. Thus, you *have* to have an evaluation effort going on in parallel with the implementation of the project. You want results, which come from the implementation, but you also want data and documentation so that you know you really have a product that does what it's supposed to do. It's not all that different from technical work. Yet people who are accustomed to the technical research model don't understand that evaluation is the place where you get your real results and learnings when you work with human systems. Without evaluation, you have no way of discerning, of learning, of making judgements, or of forging off in effective new directions. You are forced to fly by the seat of your pants, and then inferior programs are funded.

Comment from audience: Yes, I agree that DoE has not supported evaluation, and that is unfortunate.

Q: I noticed that you used house audits to estimate the energy saved by your program. Did you know that you could use residents' fuel bills and meteorological data for this year and the previous few years to estimate savings? Why didn't you do that?

A: That would have been a much more *correct* way to estimate the savings. We would have liked to have done it that way. However, you must realize that our entire evaluation budget was $100. With that kind of money, there isn't much you can do. We did our evaluation mostly "for love," out of commitment to doing some sort of reasonable job. We would have liked to look at the fuel bills, but really, we were vary ambivalent about investing as much unreimbursed time as we did on the evaluation, much less a lot more.

Q: What was the attitude of the utilities toward what you were doing? Did they resent it?

A: They didn't seem to mind at all, though I can't say we checked with them in detail. Because we do technical audits of commercial, large residential, and industrial settings, we have an ongoing relationship with them. There have not seemed to be any misgivings or friction. In fact, the residential conservation service wing of the utilities was extremely interested in our results. We spent hours talking with them, and I think saved them a good deal of money and effort. But, could you say more about what you mean?

Q: Well, what do they think about all this? How did they feel about someone horning in on what they were already doing?

A: Oh, are you talking about the issue of government's competition with the private sector through the residential conservation service and other energy-related efforts? Yes, there must be about fifty residential auditing firms in the Boston area, firms like Energy Bank and Energyworks. When Mass Save started up this year (after the onset of our project, I might add) they took about $8 million out of the middle and upper income house audit economy, and gave all the auditing work to one of those fifty firms. There have been many in the private sector who have been extremely unhappy about this. I have even heard of a possible lawsuit contending that Mass Save should be broken up in an anit-trust action. I am in contact with several of the aggrieved, and feel that I am one of the few who can speak up, because I didn't bid on the contract that the one firm got. In conclusion, I would only add that I think the Congress was probably aware of some of these problems in the legislation they enacted. They did it a few years ago, when there was a greater sense of urgency about energy conservation. We should still be feeling an urgency, and it may be that the non-competitive situation set up by RCS is a necessary, or perhaps even desirable, evil when balanced against the benefits that result from the effort. Mass Save hasn't yet had an evaluation (either formative or summative) to my knowledge, and I don't think we can make any real judgements until it has.

19.4

PATHWAYS TO THE COLLER LIFE: FOSTERING ADAPTATION TO ENERGY-CONSERVING THERMOSTAT SETTINGS

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Introduction
Functioning at reduced building temperatues during winter and increased temperatures during summer has long been recognized as a significant means of reducing energy consumption. Thus, thermostat setbacks were a national policy in the years preceding 1981, and setbacks remain in effect in many buildings even now, because they are justified on economic grounds. There is, however, an associated social/economic cost which must be minimized. Increased wintertime energy savings can lead to reduced thermal comfort and productivity, along with increased resistance to government and management, unless people are taught how to make themselves confortable and productive in cool environments. With proper education about clothing, behavior, and attitudes for improving thermal comfort, tradeoff costs can be reduced or eliminated, and new savings from energy conservation increased. Equally important, eduction can provide new options and flexibility for coping effectively with energy shortfalls such as the 1981 natural gas shock in the Boston area, during which thermostats in many gas-heated offices were set back to 55°F. Finally, educational approaches can serve to assist the many people who have already been setting back their home thermostats, in some cases to between 50°F and 60°F, to reduce their home energy consumption.

Here we present educational materials and approaches that lead people to use clothing, to develop behaviors, and to foster attitudes which are conducive to thermal comfort in cooler environments than current HVAC engineering would believe to be in the "comfort zone."* A booklet and a book on paths to thermal adaptation serve as attractive curriculum materials, and as discussion pieces that encourage people to think about how they can affect their own thermal comfort. Optional supportive materials include slides and technical readings for teachers and trainers. Portions of the total package have been used in classrooms, a govenment office, a popular-level magazine article, and self-help energy conservation workshops for lower income people.

Evidence from an evaluation of the workshops will be presented to indicate the extent to which information can be useful in a workshop designed to motivate participants. Preliminary evidence indicates that some spontaneous learning is already taking place in the population at large, and that carefully implemented educational approaches can provide significant assistance to individuals in their attempt to adapt to living comfortably and working productively at lower wintertime temperatures.

Workshop Trail of Materials and Approach
Forty self-help weatherization workshops were provided to residents of the inner city of Boston during the winter of 1980-1981. The purpose of the program was to stimulate energy conservating behavior, and to foster the implementation of cost effective energy

conservation measures in the residential sector. Publicity was aimed at low- to-lower middle income residents. The workshops were set up to motivate participants to act, and to provide them with information and instruction so that they could make informed decisions and use practical and available energy saving opportunities.

The most significant and interesting single outcome measure from the program was the setback of thermostats. The curriculum included information about such setbacks, and though this was not given any special emphasis, materials were provided to participants, and implicit emphais was given in the attitudes and role-modeling of the workshop leaders, who shared from their own experiences of living with lower temperatures. As a result of our educational intervention, along with economic and institutional forces, 95% of workshop participants voluntarily dialed back their own thermostats. The average setback was 2.1° F. This alone resulted in a savings of $23,000 in heating bills, almost as much as the Federal funds provided for offering the workshops. In addition, it should be noted that those who were able to set back their thermostats also gained personal flexibility, and contributed to institutional flexibility in coping with future energy shocks.

Curriculum

Workshop participants were presented with formal and informal curricula. The formal curriculum included methods for providing warmth and comfort while reducing energy bills. The informal curriculum was made up of the personal attitudes, experiences, and knowledge of the workshop leaders. There was also time provided for participants to share techniques and experiences with each other.

The methods people can employ to maintain warmth without expensive retrofits to their homes include winter retreat zoning, wearing additional clothing, clustering in a favored room with other members of the family, eating well, and getting exercise. A handout was made available so that participants could remind themselves later about the fine points of winter apparel for warmth. Some participants, and all workshop leaders, were provided with a copy of a popular-level article on living better with a cooler home (Foss, 1981). The purpose of sharing the article was to encourage leaders to think clearly and orginally about viable thermal comfort options, and to be willing to share their own experiences with workshop participants should the opportunity present itself. Subsequent to the workshops, an improved booklet has been initiated and made available to the public (Claman, Claman, and Foss, 1981).

The informal curriculum consisted primarily of the role modeling and the encouraging that workshop leaders could provide to participants. Leaders themselves tended to be people who set their thermostats lower than 65° F, or if they set their thermostats higher before they became leaders, they experimented voluntarily with lower temperatures once they had been introduced to the curriculum materials. The leaders therefore had a host of personal experiences with living at low thermostat settings, and they also role modeled energy conserving attitudes and behaviors without advocating them. Rigorous evaluation of the impacts of this informal curriculum must await further implementations of the model, but in the meantime, it seems reasonable to assume that workshop participants responded to such personal contact and information (based on research results and theory) by regarding thermal comfort as a personal issue worthy of their own judgement. Participants were in some cases explicitly told that, if they were careful, watching for any signs of cold stress reaction or hypothermia and dressing adequately, they could experiment with gradual further reductions in their thermostat settings.

Evaluation Method

Workshop participants were provided with registration forms when they entered the workshop facilities, and on these forms indicated whether they were interested in a follow-up house audit by the project staff. If they were interested, the project provided them with an audit within three months. They reported their thermostat settings during the 1979-1980 and the present heating seasons to the auditor. The audit also provided information about the structure of the house or apartment, so that the thermostat setbacks could be translated into fuel an dollar savings.

Results

A total of 488 people attended the 40 workshops offered. Of these, 129 people responded to the registration questionnaire, 26 reported their thermostat settings during 1979-1980, and 25 indicated their thermostat settings at the time fo the audit in late January, 1981. The mean thermostat setting dropped during the elapsed year by 2.1° F from 67.6° F to 65.5° F. Of the average 44% reduction in home energy use, 17½% resulted from such thermostat setbacks. Thus, of $57,500 estimated to have been saved in reduced energy costs as a result of the workshops, $23,000 can be attributed to thermostat setbacks.

In addition, there is evidence that people began to embrace more personal, rather than conventional, ideas about thermostat settings after the workshop. Favorite thermostat settings during 1979-1980 (before the workshop) were 65° F, 68° F, and 70° F. After the workshop, however, the 68° F and 70° F thermostat settings became much less popular. The 65° F setting remained modal, but was used by people who had previously set their thermostats higher. People who previously had set their themostats in the 65° F to 68° F range, now shifted to the 55° F to 65° F range. Thus, there was a break with conventional approaches to thermostat setbacks, resulting in significant extra fuel savings and flexibility potential in times of fuel shocks.

Discussion

It has been documented that, to the extent that selfreporting can be used to determine home thermostat settings accurately*, people reduced their settings significantly in terms of reducing energy consumption. In addition, there is evidence of attitude change. People ceased to limit their settings to those which had commonly been recommended by the EBTR standards and the media, but instead began to experiment and to rely more on their own informed judgement to determine what was appropriate for themselves.

Evaluation Design

The MEA decided to evaluate the waste heat recovery seminars to determine if the development of such industrial energy conservation seminars was a worthwhile use of limited staff time and financial resources. Such seminars have been a major component of the agency's industrial program since 1978. Evaluation findings will be useful in designing future state-sponsored energy conservation programs for business and industry. The evaluation included a written questionnaire distributed to participants at the workshop, and a telephone survey administered about one year after the seminars were offered.

The purpose of the written questionnaire was to elicit the attendees' immediate reaction to the seminar in terms of satisfaction with the program and attitude toward waste heat recovery. In addition, information was collected on participant characteristics, how they heard about the seminar, the types of projects they would implement, and what other energy conservation topics would be of interest to them.

The purpose of the telephone survey was to determine what heat recovery actions participants had taken in the year following the seminars, reasons projects had not been implemented, and the extent to which participants perceived the seminar had influenced their consideration of a waste heat recovery project. The effectiveness of the seminars in stimulating action was also determined by administering the phone survey to a group of individuals who had requested the MEA manual on waste heat recovery but had not attended the seminar. The rationale for using this group for comparison was that those who had made made the effort to request the manual were self-selected similarly to the way that seminar attendees were self-selected. Both demonstrated some prior interest in energy conservation. Comparisons between the two groups were used to determine whether seminar participants were more active in heat recovery projects than manual recipients.

The evaluation was based on the responses of:

- 268 seminar participants (76% of the 353 attending) who completed a written questionnaire directly after the seminar,
- 222 seminar participants (60%) interviewed by telephone one year later,
- 78 others who requested the waste heat recovery manual from MEA but did not attend a seminar (61% of those who requested the manual directly from the MEA). This group was also interviewed by telephone.

Respondent Characteristics
Thirty-four percent of the seminar participants were from industries (manufacturing and mining) and 36% were from institutions (schools, health care, government), with fewer representives from the commercial sector (16%) and other types of organizations (14%). Over half the manual recipients (56%) were from industry; most of the remainder were equally divided between the institutional (19%) and commercial (19%) sectors, and 6% represented other areas. The "other" category consisted primarily of utilities, engineering contractors, and heat recovery manufacturer's representatives.

Engineers comprised the highest category of respondents (43%), followed by managers (29%), then engineer/managers (15%), financial officer/managers (2%) and financial officers (1%). The "other" category (10%) consisted primarily of consultants, maintenance personel, and information/education professionals. The proportions were similar for both seminar and manual groups.
Although the largest category of respondents represented organizations with fewer than 100 employees, small organizations were actually under represented when compared with the large proportion of small organizations in the state.

Participant Satisfaction
Information regarding the participants' level of satisfaction with the seminars was collected by the written questionnaire at the end of the seminar. A series of multiple choice questions asked participants to rate various aspects of the seminar on a scale of excellent to poor. In general, participants appeared quite satisfied with the written materials, instructor, and overall effectiveness of the seminar. Every item had significantly more positive than negative ratings (Table I). Averaging the responses within these three categories, the instructor and materials category were rated more favorably than overall effectiveness (Table II).

Areas of dissatisfaction with the seminar were related to the difficulty of covering a broad topic for diverse audience in short time. Some attendees commented that the seminar did not go into enough technical detail; others thought that it was more oriented toward other types of organizations. It is clear that time constraints prevented full discussion of all heat recovery applications of interest to attendees.

Implementation of Waste Heat Recovery Projects by Participants
At the conclusion of the seminar, a high proportion (73%) of written survey respondents stated their intention to implement a waste heat recovery project. One year later, phone survey respondents were asked whether they actually took action. Fifty-four percent had considered a project, 28% began to implement at least one project, and 15% had completed at least one project at the time of the survey (Table III). Since waste heat recovery is a conservation measure that involves substantial investment of time and money, these findings are encouraging.

Some groups of participants took more action than others. A higher percentage of participants from industry (77%) considered heat recovery projects than did those from institutions (56%) or businesses (27%). Large organizations were more active in project consideration and implementation than smaller organizations.

Respondents were asked to select, reasons for not implementing a project. Financial reasons were cited most often as the major reason for not implementing waste heat recovery projects. One-third of those responding had decided that such a project was not cost-effective for their organization, and 22% said that other capital improvements had a higher priority. The lack of front end capital was also cited in open-ended comments as a reason for non-implementation. "It was not technically feasible" and "Haven't had time to work on it" were reasons cited with about the same frequency (13% and 14%, respectively).
The least often cited reason (3%) was "lack of information on how to go about it." This finding does not necessarily mean that lack of information is not a barrier to implementation. While participants felt they were well-informed, it is not known how well they transmitted their knowledge to others in their organization who make final investment decisions.
Other responses mentioned lack of government funding, health or safety regulations, the work being in progress, or technical limitations.

Effect of the Seminar on Participant Behavior
The effectiveness of the seminar in stimulating concrete actions was examined in two ways. One was by asking attendees to report how much they felt the seminar influenced their actions. About 15% of all seminar attendees had begun to implement a project and stated they were "a great deal" or "somewhat" influenced by the seminar. Furthermore, about one-third of all attendees reported being influenced by the seminar to consider a project. Comparison with a group of waste heat manual recipients suggests that each group perceived the influence of the service they were exposed to about equally (recognizing differences between the questions asked respondents).

The second way of examining seminar effectiveness was to compare seminar and manual groups in terms of consideration and implementation of projects. In the year following the seminar, 55.3% of the seminar attendees and 50.0% of the manual recipients considered a project — not statistically significant at the .1 level. When the two groups were adjusted to have the same composition of industrial, commercial, and institutional representatives, about 10% more of the seminar participants considered a project than the manual recipients — still not a statistically significant difference. Likewise, no significant difference was found in the percentage which had begun to implement a project.

Thus, according to the self-reported perceptions, the seminars were effective in stimulating consideration and implementation of waste heat recovery projects. However, in comparisons of perceived influence and actions taken, they do not appear to be more effective than a written manual on the same subject.

Cost Effectivenss
The cost-effectiveness of the seminars was examined from three perspectives. First, did the sponsors of the seminars recover the expenses associated with offering the seminars? The cost of the seminars to the MEA and its cosponsors was estimated to be $13,100 or $37/attendee. The cost to the MEA alone was about $2,700 or $7.60 per attendee. Registration fees totaled $10,590, which covered everything except cosponsor staff time and mailing costs.

Second, did the heat recovery projects stimulated by the seminars produce energy savings greater than the cost of the projects and the seminars? Data is not available to determine whether the dollar value of energy saved resulting from seminar-stimulated actions is greater than the cost of the seminars plus the cost of the projects. However, some judgements were made about the cost-benefit of the seminars from a societal perspective. Based on survey response, 53 waste heat recovery projects have been initiated to date which can be attributed to the seminars. If all seminar costs were divided equally among these projects, they would add about $247 per project to implementation costs from a societal perspective. According to MEA staff, the added $247 would not jeopardize an otherwise favorable cost-benefit ratio.

Third, are seminars or manuals a more cost effective means of providing information about waste heat recovery? Based on seminar participation of 353 and the total manual distribution of 2689, the seminar cost about $33 more than the manual per person served. In terms of cost to the MEA alone, the seminar cost about $3.00 more per person than the manual. Although these are estimates, it is evident that the heat recovery manual is a much less expensive information channel per recipient than the seminar. There was no significant difference in the percentage of seminar and manual groups initiating heat recovery projects, indicating that both channels were about equally effective in stimulating action. The magnitude of cost differences strongly suggests that the manuals were more cost effective than the seminars in stimulating waste heat recovery activities.

Conclusions and Recommendations
The major conclusions from the evaluation are as follows:

- Participants were generally quite satisfied with the seminars: 60% to 96% rated different components good or excellent.
- The seminars' major shortcoming was that they covered too broad a topic in too short a time for an audience which was diverse in type of organization and position in organization.
- Seventy-three percent of the participants said they definitely or very likely intended to implement a project after the seminar. 54% of the participants considered a heat recovery project in the year following the seminar, 28% began implementation of at least on project, and 15% completed a project.
- The level of waste heat activity varied significantly with industries being most active, followed by institutions, followed by business. 1Large organizations were more active than small organizations.
- Cost was cited most often as a reason for non-implementation of projects; lack of information was rarely cited.
- The seminars were effective in stimulating about one-third of all participants to consider a project and about 15% to begin project implementation.
- Comparing costs and benefits to society, the seminars are judged to have a positive cost-benefit ratio.
- There was no significant difference in the effectiveness of the seminar and the manual in stumulating action on waste heat recovery.
- The manual on waste heat recovery appears more cost effective than the seminar.

These conclusions give rise to three key recommendations:

- The MEA should continue to offer educational/informational services on waste heat recovery based on the high level of interest and their overall cost effectiveness.
- The MEA should conduct additional research on:
  a) the reasons for variation in heat recovery activity among organizations of different types and sizes and,
  b) how informational/eductional services can most cost effectively provide the information and motivation needed for implementation of projects.
- If both educational programs and written materials on heat recovery are offered in the future, they should be designed to fully exploit their respective attributes as information delivery mechanisms and used in a complementary manner. While further research is needed on how to do this, one strategy would be to distribute the lower cost manual to a broad audience first. Then, different seminars which provide in-depth treatment of specific heat recovery topics could be offered for groups within the broad audience.

TABLE I

Participant Satisfaction with Seminar

(N = 268)

	Excellent	Good	Fair	Poor
Written Materials				
Overall usefulness	34%	57%	9%	1%
Usefulness of list of manufacturers	32	54	14	1
Quality of diagrams and figures	29	59	12	1
Ease of comprehension	22	67	10	1
Usefulness of examples	21	62	16	1

Instructor				
Overall effectivenss	25%	56%	17%	2%
Knowledge of subject	50	46	4	0
Ability of answer questions	39	48	131	
Overall effectiveness of the workshop				
Relation between instructors presentation & written materials	26%	64%	10%	1%
Appropriateness to your operation	11	49	37	3
Organization of subjects covered	11	69	19	1
Completeness of subjects covered	10	56	32	2

TABLE II

Summary of Participant Satisfaction

	(N = 268) Excellent or Good Subtotal	Excellent	Good	Fair	Poor
Written Materials	86.0%	29.5%	56.5%	13.3%	0.1%
Instructor	87.6%	38.1%	49.5%	11.4%	0.1%
Overall effectiveness	73.9%	14.5%	59.4%	24.3%	0.2%

TABLE III

(N = 222)

Percentage of Seminar Attendees Intending to Take or Taking Action	
Intended to Implement Project	73%
Considered Project	54%
Began to Implement Project	15%

19.5

EFFECTIVENESS OF STATE-SPONSORED SEMINARS IN STIMULATING CONSERVATION ACTIONS BY PRIVATE BUSINESS*

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Abstract

This paper describes a two-stages evaluation conducted on a series of waste heat recovery seminars held in early 1980. The seminars, which were sponsored by the Minnesota Energy Agency and several cosponsors, were held at five locations throughout Minnesota. Participants primarily represented industries, businesses, or public institutions and classified themselves as engineers, managers, or budget/financial personnel. The seminars were intended to familiarize participants with various aspects of waste heat recovery, and provide them information necessary to apply heat recovery concepts to their organizations. The seminars also presented methods for determining technical and economic feasibility.

The first stage of the evaluation was a written survey administered at the end of the seminar. It determined levels of participants satisfaction with the instructor, written materials, and overall effectiveness of the seminar. It also asked participants whether they intended to implement a waste heat recovery project.

The second stage of the evaluation consisted of a telephone survey administered approximately one year after the seminars. Its purpose was to determine what actions seminar participants had taken since the seminars, reasons for not taking action, and how they felt about the seminar after one year. It also compared their actions with those of a group of individuals who had received a manual on waste heat recovery but had not attended the seminar.

Introduction

The Minnesota Energy Agency (MEA) has offered a variety of education programs to stimulate energy conservation in industries, institutions, and businesses. This report evaluates the effectiveness of waste heat recovery seminars offered by the MEA in 1980. Waste heat is thermal energy which is released into the environment before it has been fully utilized. Energy consumption can be reduced by recovering and re-using this waste heat. Waste heat recovery is matching a source of waste heat in a building with some other heating or process need for that energy and then finding the proper recovery device to connect the two. The major goal of the seminars was to motivate participants to investigate the potential for waste heat recovery in their facilities.

A. Background on the Seminars
The Minnesota Energy Agency and sevaral cosponsors offered five oneday waste heat recovery seminars during February and March, 1980. The seminars were designed to increase participants' knowledge of:

- various aspects of waste heat recovery,
- opportunities for waste heat recovery,
- equipment options available to recover heat,
- econonic analysis to determine if acceptable paybacks can be achieved,
- low and high temperature applications through case studies.

The target audience included business and industry personnel in the areas of administration, supervision, plant operation, plant engineering, building management, and energy management.

Presentations by the seminar instructor were supplemented by written materials including a manual published by the MEA *(Minnesota Guide to Waste Heat Recovery)*.

B. Evaluation Design
The MEA decided to evaluated the waste heat recovery seminars to determine if the development of such industrial energy conservation seminars was a worthwhile use of limited staff time and financial resources. Such seminars have been a major component of the agency's industrial program since 1978. Evaluation findings will be useful in designing future state-sponsored energy conservation programs for business and industry. The evaluation included a written questionnaire distribued to participants at the workshop, and a telephone survey administered about one year after the seminars were offered.

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Effect of the Seminar on Participant Behavior

The effectiveness of the seminar in stimulating concrete actions was examined in two ways. One was by asking attendees to report how much they felt the seminar influenced their actions. About 15% of all seminar attendees had begun to implement a project and stated they were "a great deal" or "somewhat" influenced by the seminar. Furthermore, about one-third of all atendees reported being influenced by the seminar to consider a project. Comparison with a group of waste heat manual recipients suggests that each group perceived the influence of the service they were exposed to about equally (recognizing differences between the questions asked respondents).

The second way of examining seminar effectiveness was to compare seminar and manual groups in terms of consideration and implementation of projects. In the year following the seminar, 55.3% of the seminar attendees and 50.0% of the manual recipients considered a project — not statistically significant at the .1 level. When the two groups were adjusted to have the same composition of industrial, commercial, and institutional representatives, about 10% more of the seminar participants considered a project than the manual recipients — still not a statistically significant difference. Likewise, no significant difference was found in the percentage which had begun to implement a project.

Thus, according to the self-reporting perceptions, the seminars were effective in stimulating consideration and implementation of waste heat recovery projects. However, in comparisons of perceived influence and actions taken, they do not appear to be more effective than a written manual on the same subject.

Cost Effectiveness

The cost-effectiveness of the seminars was examined from three perspectives. First, did the sponsors of the seminars recover the expenses associated with offering the seminars? The cost of the seminars to the MEA and its cosponsors was estimated to be $13,000 or $37/attendee. The cost to the MEA alone was about $2,700 or $7.60 per attendee. Registration fees totaled $10,590, which covered everything except cosponsor staff time and mailing costs.

Second, did the heat recovery projects stimulated by the seminars produce energy savings greater than the cost of the projects and the seminars? Data is not available to determine whether the dollar value of energy saved resulting from seminar-stimulated actions is greater than the cost of the seminars plus the cost of the projects. However, some judgements were made about the cost-benefit of the seminars from a societal perspective. Based on survey response, 53 waste heat recovery projects have been initiated to date which can be attributed to the seminars. If all seminar costs were divided equally among these projects, they would add about $247 per project to implementation costs from a societal perspective. According to MEA staff, the added $247 would not jeopardize an otherwise favorable cost-benefit ratio.

Third, are seminars or manuals a more cost effective means of providing information about waste heat recovery? Based on seminar participation of 353 and the total manual distribution of 2689, the seminar cost about $33 more than the manual per person served. In terms of cost to the MEA alone, the seminar cost about $3.00 more per person than the manual (Table IV). Although these are estimates, it is evident that the heat recovery manual is a much less expensive information channel per recipient than the seminar. There was no significant difference in the percentage of seminar and manual groups initiating heat recovery projects, indicating that both channels were about equally effective in stimulating action. The magnitude of cost differences strongly suggests that the manuals were more cost effective than the seminars in stimulating waste heat recovery activities.

Conclusions and Recommendations

- Participants were generally quite satisfied with the seminars; 60% to 96% rated different components good or excellent.
- The seminars' major shortcoming was that they covered too broad a topic in too short a time for an audience which was diverse in type of organization and position in organization.
- Seventy-three percent of the participants said they definitely or very likely intended to implement a project after the seminar. 54% of the participants considered a heat recovery project in the year following the seminar, 28% began implementation of at least one project, and 15% completed a project.
- The level of waste heat activity varied significantly with industries being most active, followed by institutions, followed by businesses. Large organizations were more active than small organizations.
- Cost was cited most often as a reason for non-implementation of projects; lack of information was rarely cited.
- The seminars were effective in stimulating about one-third of all participants to consider a project and about 15% to begin project implementation.
- Comparing costs and benefits to society, the seminars are judged to have a positive cost-benefit ratio.
- There was no significant difference in the effectivenss of the seminar and the manual in stimulating action on waste heat recovery.
- The manual on waste heat recovery appears more cost effective than the seminar.

These conclusions given rise to three key recommendations:

· The MEA should continue to offer educational/informational services on waste heat recovery based on the high level of interest and their overall cost effectiveness.

·The MEA should conduct additional research on:

a) the reasons for variation in heat recovery activity among organizations of different types and sizes and,

b) how informational/educational services can most cost effctively provide the information and motivation needed for implementation of projects

· If both educational programs and written materials on heat recovery are offered in the future, they should be designed to fully exploit their respective attributes as information delivery mechanisms and used in a complementary manner. While further research is neded on how to do this, one strategy would be to distribute the lower cost manual to a broad audience first. Then, different seminars which provide in-depth treatment of specific heat recovery topics could be offered for groups within the broad audience.

·This paper is a condensed version of a report which can be obtained by contacting the author at the above address. Preparation of the report was funded by a grant from the U.S. Department of Energy.

19.6

A UNIVERSITY-BASED ENERGY EDUCATION PROGRAM FOR MASSACHUSETTS RESIDENTS

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Introduction

The last decade has been a time of intense challenge to our society's perceptions about industrial productivity, consumption of natural resources and economic growth. For the first time, we have had to confront a sense of absolute limits to all three. As economic conditions change in the United States and in other countries, it is essential that individuals and economic entities including businesses, households, community organizations and government entities, change their beliefs and behavior accordingly. To maintain solvency and well-being in the face of inflation, recession, commodity shortages and public funding cutbacks, adaptability and creativity are required at all levels of social organization and economic decision-making.

In New England, the most significant threat to our economic well-being is the rising cost of energy. The region is 80 percent dependent on oil for its energy supply, almost all of it imported oil. Fuel costs for residential, commercial and municipal space heating, industrial process and space heat, and electric utilities are among the highest in the nation. This situation, coupled with the severity of New England's winters, constitutes an extraordinary burden on energy consumers. In response to this situtation, consumers are altering their energy-consuming behavior. Average household use of oil for space heating has decreased 16 percent since 1973, and growth in demand for electricity has virtually ceased in the last two years.

There is a growing consensus in the region that conservation is the most promising alternative to present energy sources, and that cost-effective technologies exist to reduce consumption of oil, natural gas and electricity by at least 25 percent in the next decade. However, the adoption of conservation requires an entirely new approach to energy investment decision-making. To develop traditional energy resources, a relatively small number of producers make large investments in power plants, oil and gas fields, and other forms of intensive energy production. The conservation process, on the other hand, requires that multitudes of energy consumers, both large and small, make individual investments to purchase and install energy-conserving measures. Because the economic viability of households, businesses and municipalities in New England increasingly depends on the degree to which they are able to control expenditures for purchased energy, consumers are finding themselves needing to make informed decisions about diverse and rapidly maturing energy conservation and alternative energy technologies.

One implication of this sitution is that consumers need access to both information and analytical skills that will enable them to quantify the impact of various energy-conserving strategies and to effectively implement the strategies. The Energy Education Center, a special program within the Division of Continuing Education of the University of Massachusetts in Amherst, recognizes this need and is actively involved in innovating educational programming to address it. Sixteen different courses have been developed to help homeowners, residents and owners of multi-family housing, business decision-makers, municipal officials, school administrators, and energy conservation professionals to gain competence in all aspects of energy conservation, energy management and utilization of alternative fuels.

Program History

The programs currently offered by the Energy Education Center are the direct result of four years of energy education acitivity at the University of Massachusetts. In 1977, the Energy Education Center was founded to provide training, technical assistance and administrative support to seven teams of residentail energy conservation technicians who were hired by county extension offices using C.E.T.A. public service employment funds. The purpose of this program, called the Energy Conservation Analysis Project (E.C.A.P.), was to provide households with information that would enable them to conserve energy effectively. E.C.A.P. technicians conducted on-site home energy audits that included: (1) an interview with the homeowner or other household members, (2) measurement and assessment of the home's heat loss areas, (3) a furnace efficiency test, and (4) calculation of the home's heat loss and potential energy savings from recommended improvements. A written report containing the auditor's findings was sent to the household. This was the first major energy auditing program in New England. In the three years that ECAP was in operation, more than 8,000 audits were conducted by about 150 technicians. Over 75 percent of the households that received audits made some kind of energy-conserving capital improvement following the audit. Overall energy savings were estimated to be about 15 percent.

A parallel program was established in 1978 to serve the municipal sector. The Municipal Energy Conservation Analysis (M.E.C.A.P.) employed and trained 60 technicians who provide energy management assistance to school systems and other municipal agencies. M.E.C.A.P. personnel performed energy audits on more than 280 public buildings.

Later in 1978, the Energy Education Center was one of twelve organizations in the nation selected to demonstrate the feasablility of low-cost solar heat for existing housing. This program, known as Solar Utilization, Economic Development and Employment (S.U.E.D.E.), was funded by the Department of Energy, Department of Labor and Community Services Administration to (1) demonstrate a training methodology for solar installers, (2) demonstrate the feasability of three low-cost passive solar designs for installation on existing houseing, and (3) provide assistance in reducing energy use for a group of low-income homewoners. After attending a ten week training program, Energy Education Center crews installed twenty-nine solar greenhouses, wall-mounted air panels and direct-gain glazing systems on low-income homes in Franklin and Hampshire Counties.

These three programs (E.C.A.P., M.E.C.A.P., and S.U.E.D.E.) provided the Energy Education Center with an unique body of experience in skills training, community education and technology transfer. In recognition of this experience, the Department of Energy selected the Energy Education Center to write the energy auditor training manual for the nationally-mandated Residential Conservation Service Program. The intent of the R.C.S. Program is to use the regulated gas and electric utilities as a network to provide between 5 and 10 million residential customers with energy audits and other conservation services. If carried out, this task will require the services of over 10,000 trained energy auditors. The 500 page *R.C.S. Energy Auditor Training Manual*, completed by the Energy Education Center in July, 1980, is widely acclaimed both for its technical comprehensiveness and for its educational effectiveness.

Since the beginning of 1980, the Energy Education Center has conducted numerous energy technician training programs for utilities, state and federal agencies, community action agennies, conservation businesses, municipalities and trade associations. Each program is specifically designed to meet the personnel development needs of the sponsoring organization. Several of these programs have been "train the trainer" programs in which participants learn not only energy conservation skills, but also how to conduct training, supervision and quality control for their organization.

Role within the University

For almost four years, the Energy Education Center was affiliated with the Massachusetts Cooperative Extension Service, which is based at the University of Massachusetts and has offices in each county in the state. The Cooperative Extension Service is the arm of the University's College of Food and Natural Resources responsible for providing community education and technical assistance in agriculture and natural resource managment to the residents of the state. The original purpose of th Energy Education Center was to provide Massachusetts households with direct technical assistance in their efforts to reduce energy consumption. To accomplish this, it was necessary to develop a workforce skilled in residential energy conservation. In the process of employing and training this workforce, the Energy Education Center became a national leader in energy-related skills training.

In order to strengthen its focus on occupational education and skills training, the Center changed its affiliation in early 1981 and became a special program within the Division of Continuing Education. Under the direction of the Associate Provost for Continuing Education and Public Affairs, the Divsion of Continuing Education addresses the educational needs of Massachusetts residents other than full-time college and university students. The Division offers evening courses for part-time graduate and undergraduate students, professional development seminars, credit-free workshops, community affairs programs, and special programs in basic career, communications and learning skills. With its broad range of program content areas and formates, the Division of Continuing Education offers an environment in which the Energy Education Center has the flexibility to respond to the diverse educational needs of individuals, community organizations and businesses in the region.

Current program

The Energy Education Center has made an effort to identify the energy related educational needs of New England residents. Four different groups with distinct educational needs have been identified: (1) Individual energy consumers, (2) individuals seeking professionals skills in energy conservation, energy management, and renewable resource utilization, (3) organizations, such as community action agencies, housing rehabilitation programs, public utilities and conservation businesses, that have extensive energy conservation programming responsibilities, and (4) businesses, municipalities and other entities needing to reduce their energy expenditures. The Center's intention is to offer programs that meet the needs of each of these groups, both in terms of content and program format.

For individual energy consumers, the Energy Education Center has several program options. On an introductory level, 1½ hour seminars on no- and low-cost energy conservation practices, home weatherization, solar heating, and heating with wood are offered. These seminars can be sponsored by employers, municipalities or community organizations and offered anywhere in Massachusetts. For consumers wanting more depth of information, a number of evening and weekend courses designed to give participants practical energy management skills that they can use to reduce home energy consumption are offered at the University. These courses, which range in length from 8 to 16 instructional hours over a period of one to four weeks, include: "The Energy-Efficient House", "The Billpayer's Guides to Home Heating Systems", "How to Assess the Solar Potential of Your Home", and "Solar Greenhouses for Home Heat and Food Production".

The core of the Energy Education Center's current offerings is a series of energy technician training programs designed to impart a wide array of career-related skills in energy management, energy conservation, and renewable resource utilization. These programs include:

- "Residential Energy Auditing and Weatherization", a 40 hour program providing complete professional training for residential energy auditors.
- "Energy Management in Large Buildings", a 40 hour program that provides participants with the skills needed to recognize, analyze and correct wasteful energy use in large and multi-use buildings.
- "Solar Design Fundamentals" and "Advanced Passive Solar Design", two 35-hour programs for architects, builders and other housing professionals designed to provide a complete working knowledge of solar design techniques.
- "Lifecycle Costing Seminar", an eight hour program introducing a method for comparing the economic desirability of energy conservation and alternative energy options.
- "Solar Installation Workshops", a series of 16 hour programs in which participants construct and install a variety of sitebuilt solar collectors.

- "Wind as an Energy Source" and "Small Wind Energy Conversion Systems: Design and Installation", two 40-hour programs designed to provide participants with the skills needed to perform site asessments, select and interface system components, and perform a complete wind system installation.

These programs are offered in a variety of time formats and geographical locations to make them available to as many people as possible. Time formats include: five consecutive 8 hour days; Friday evening and all day Saturday and Sunday; and three evening hours twice a week for six or seven weeks. Most of our energy technician programs are held on the University of Massachusets campus at Amherst. Some are held in the Boston area, and when a suitable training site is located in Southeastern Massachusetts, programs will be held there.

Organizational structure

The Energy Education Center has four trainers and one administrator with training responsibilities on staff. Three other administrators are responsible for public relations, marketing, program development, fiscal administration, University relations and logistical support of training programs. The majority of funds for salaries and other program expenses is obtained from course tuition and from training and technical assistance contracts. We have established a fee structure that allows trainers to average 16 contact hours and 24 hours of preparation, research and program development per week. This arrangement is central to our ability to maintain the technical and educational quality of our programs.

Conclusion

Over the last four years, the Energy Education Center has demonstrated that the public university can play a significant role in many aspects of energy education, including direct community education, demonstration projects and occupational education. In keeping with changing political and economic realities, the funding base for these activities has evolved from primarily state and federal grant funding to primarily fee-for-service funding. These changes have forced the University of Massachusetts to abandon its state-wide network of energy educators but have done nothing to hinder the increasing scope and quality of its on-campus energy education programs. The Energy Education Center can serve as a model of effective program design and regional service delivery applicble to other public educational institutions.

19.7

EDUCATING THE CONSUMER - A NEW CHALLENGE

Judith Pariseau

Abstract

The need for consumer education on solar energy alternatives has never been greater. The deregulation of fuel prices coupled with the elimination of federal programs that were designed to accelerate the adoption of renewable energy products creates a new challenge for the educator, local government official and homeowner. The challenge is to develop programs of energy information exchange for all consumers, so that informed decisions about energy utilization can be made. It is possible to incorporate the functions of existing institutions and organizations inthe process of energy information exchange, but to do so requires a new kind of planning that is based on synthetic thinking rather than analytical thinking.

A preferred state of energy utilization might be described as: providing the energy needs of all people without burdensome financial costs, damage to the environment or reducing the lifestyle we now enjoy. If we continue with the present system of energy utilization, we will guarantee that none of the items described in this preferred state will be made possible for any one of us to have. We need to change our energy use patterns and technologies. "Broadly speaking, the nation has only two major alternatives for the rest of the century-to import more oil or to accelerate the developement of conservation and solar energy."[1]

Although solar technology is not an innovation (it has been in use since the Greek and Roman civilations), consumers view it as an innovation and it should be treated as such. The diffusion of an innovation "or the process by which a new idea or product spreads among individuals, and/or organizations in a social system"[2] requires education and information to reduce the dissonance between the consumers initial perception and final adoption of the innovation. The consumer passes through the cognitive level (awareness of the innovation), to the affective level (developing an interest or preference for the product), and finally reaches the action level (the purchase of the product). To date, solar market studies show that the solar consumer enters into a two to two and a half year information search before purchasing equipment. "As the market diffusion process continues, it is assumed that the consumer will represent a cross-section of the American homeowner. Solar consumers are generally uninformed about the potential of solar systems and feel that more information is needed."[3] The federal government has created several programs over the past years to deal with the consumer's need for energy information. The future of these programs is dubious and certainly not a priority under the present federal administration. It is time, therefore, to take on the challenge of creatively planning our energy future of which educating the consumer is an intergral part.

"Present-day energy planning can be categorized as the attempt to solve fifty -year global problems with four year local solutions staffed with two year personnel funded with one year allocations that have been budgeted by bureaucrats who can not see more than six months, the next election, or vacation (which ever comes first) in advance and who know next to nothing about energy other than it does not, like other problems, go away if ignored. It is an attempt to solve vast problems with half-vast solutions."[4] Faced with the need for energy planning, of which consumer education is a part, we now have the opportunity to utilize other planning methods to solve our energy problem, sans federals dollars.

"There are three kinds of things that can be done about problems — they can be resolved, solved or dissolved."[5] To resolve a problem means that the outcome is "good enough". The method is based on the trial and error of past events, is qualitatively oriented and is subjective. To solve a problem means that the best possible outcome is the goal. This method is scientific and mathmatical in its approach, is quantitative and objective. To dissolve a problem means to remove it. This method changes the characteristics of the larger system within which the problem exists. This is the design approach and uses a synthesizing rather than analytical approach to problem solving. "Nevertheless, few if any problems are ever permanently resolved, solved or dissolved. Every treatment of a problem generates new problems."[6] When we experience a multitude of problems that are associated with a specific need (like the need to disseminate information to many different types of consumers who have varying energy needs and who are marginally interested in adopting a new innovation because they live in a culture that regards energy consumption as a right and discourages the exchanges of factual information in its popular and widespsread communication vehicles) we experience a "mess."[7] A mess requires planning that uses synthesizing thinking rather than analytical thinking.

To create a plan to dissolve a mess that a system confronts, analysis of the parts of the system and/or a clinical approach of looking at the system in general, will not achieve the desired result. Both things must be done. To clearly understand the nature of the problem for the system in trouble the following steps should be taken:

1. Identify the larger system(s) within which the troubled system exists.
2. Identify the nature and behavior of the larger system(s).
3. Explain the role of the smaller system to the larger system.

Disemminating energy information to consumers is a system that is couched in the three following systems:

SYSTEM	NATURE/BEHAVIOR
Life Support, food, energy.	Provides well being for all.
Business, goods & services.	manages product and market exchange.
Communication, education, media.	Transfers information.

The role of the system of energy information exchange in the larger system of Life Support can be equated to the thousands of our ancestors who continually ate berries, constantly experimenting to see which ones would make them die or be ill. Proven solutions that guarantee life support should be communicated to the rest of humanity. The role of energy information exchange information exchange in the system of business is that the exchange enhances the process product and market exchange by reducing the dissonance of the customer's perception of the product. The role of energy information exchange in the system of communication is that it provides a source of pertinent and meaningful information that the communication system can use. The point is that each one of the larger systems has a vested interest in the smaller system. When creating programs for the exchange of energy information keep in mind not only what needs to be communicated and to whom, but also the environment within which the need exists.

This method of designing has already created programs for the exchange of energy information that are not dependent on federal dollars. For instance, a national television station was approached with the idea that during their evening news program they could run a series of successful solar and conservation spots, that solar companies in the area would advertise during the time period and that local energy experts would be used for technical advice and support. Consumers will receive new information on solar and conservation - about what is possible. The television station, hungry for stories, will receive good programming. The solar businesses will benefit from the information exchange and the advertising. Everyone wins.

Footnotes

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19.8

A WOOD HEAT SAFETY & OUTREACH PROGRAM FOR FRANKLIN COUNTY, MASS.

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Introduction

The present energy crisis has prompted many people to install wood burning equipment for primary or supplemental heat. An ever-increasing number of people, inexperienced in heating with wood, are beginning to use wood stoves. Wood use has increased 20% or more since 1978 in Massachusetts, and there is no sign that the trend is slowing. Fifty-one percent of wood-burning households polled indicated they had been using wood for four years or less. Approximately 526,000 households in Massachusetts burn some quantity of fuel wood in fireplaces and wood stoves. Of the Massachusetts residents not burning wood, one in seven described themselves as very likely to buy a wood stove or furnace within the next three years. The increased danger of fires is dramatically represented in the survey of wood burning households; one in 25 households reported a house fire caused by firewood between 1973 and 1979 (Berkshire-Franklin Resource Conservation & Development Report, 1979).

During the winter of 1977-1978, 279 wood stove related fires were reported; of those 279 fires, it was reported that one fire was caused by a faulty wood stove. Virtually all of the other 278 fires were caused by improper installation, maintenance and operation of the wood burning unit. During 1979, 175 fires related to wood stoves were reported, twenty-nine fires caused by faulty stoves, nineteen caused by faulty pipes, thirty-two caused by improper operating procedures, including careless use and overfiring of the stove. Forty-five were caused by improper installation and fifty caused by inadequate maintenance. Propety damage totaled as high as $60,000 (State Fire Marshall's Report, 1978 & 1979). According to the "Review of Fire Incidents, Model Building Codes & Standards Related to Wood Burning Applicances," the most important areas of concern for preventing fires are installation, operation and maintenance of wood stoves and furnances. The report suggested that criteria and instruction for installation be provided to the public because the majority of wood-burning units are installed by residents, rather than by professionals (Peacock, 1979)

The Massachusetts Cooperative Extension Service, because of its comprehensive community network and broad base of experience in publishing technical information and public education, was able to develop a method for providing the public with the necessary information. The Cooperative Extension Service, through the Energy Conservation Analysis Project (ECAP), hired me to serve in the position of wood stove safety advisor between June, 1977 and December, 1979 in Franklin County, Massachusetts. The position was created on the premise that people were reluctant to call a building inspector who had the authority to order removal of a stove or to deny a permit. Therefore, if there were not a confidential source of accurate information, these persons might not have obtained the necessary safety information.

For example, during this period, the state building code required a building permit before installation of wood burning devices. As of January 1, 1980, all wood burning devices installed in Massachusetts must also be tested and approved by an approval testing lab. These requirements are administered by the State Building Code Commission through local building inspectors. Yet, I consulted with 230 households who burned wood; of those, only 25 had obtained building permits before the installation of the unit. So, clearly this position did not duplicate the role of the building inspector.

Development

The wood stove safety advisor's duties were:

1. to provide individual consultation for home safety analysis of wood buring equipment,
2. to provide workshops and siminars to interested community groups, and
3. to act as a consumer advocate and provide impartial, generic information on stove types.

The first two tasks undertaken were:

1. researching pertinent technical information, and
2. meeting with building and fire department officials.

A large body of technical information came from wood stove manufacturers and dealers, The National Fire Prevention Association, the National Refrigeration Air Conditioning Engineering Society, and Bob Martin, the Farm and Home Safety Specialist at University of Massachusetts. Product literature obtained from manufacturers was compiled in notebooks and was a useful resource for potential wood users. The wood stove safety advisor did not provide editorial comment on specific stoves but did provide generic information on types of stoves. Safety information obtained from the above resources was distributed to county residents.

The advisor handled issues over which the building inspector and fire departments had jurisdiction. Therefore, good relationships with these regulatory agencies were essential. Before the public was informed of the wood stove advisory services, letters of introduction were written to 52 building inspectors and fire department officials serving the 26 towns in Franklin County. Along with informing the officials of the intended safety advisory service, their expertise was called upon to aide the neophyte safety advisor in technical areas. It was stressed in each correspondence that the advisor would function in an advisory capacity and would in no way infringe upon their jurisdiction.

Those officials who responded to the letters were most helpful in providing valuable information and acted as a resource to the safety advisor for the duration fo the program. For example, Bob Martin, Farm & Home Safety Specialist for the Extension Service, was an invaluable resource who consistently provided information, materials, and support. Calling on the experts within the community served to establish collborative working relationships where the potential for competition existed.

Local wood stove dealers and manufacturers were also informed of the upcoming advisory service. They too, provided valuable technical and commercial information to the program.

Within two months the advisor learned technical information, established relationships with regulatory agencies, acquired safety pamphlets for distribution, and collected information from stove manufactureres and dealers, and designed the program format.

Implementation

The outreach and public education campaign began. A publicity strategy was developed and implemented to make the wood stove safety advisory service available to as many people as possible. Flyers advertising the service and stressing its confidentiality were printed and posted in stores and community meeting places throughout the county. Newspaper articles and open-mike programs on local radio stations announced the service. Local television stations on occasion were also called upon to draw attention to wood stove safety. Both wood users and perspective wood users (having heard of the program through various channels) contacted me for individual safety consultations. The following is a list of issues addressed during the consultations:

Nature of codes and standards
Minimum safety standards
Clearance reduction materials
Installation and types of stove pipe
Sizing stove for area to be heated
Type of wood stoves and their features

Type of fuel, wood, coal, heat content, safe handling and storage
Ignition procedures
Draft principles and controls
Care and maintenance of equipment
Circulation of heat in a building
Smoke and dust problems
Thermostat setting with new heating device
Humidity problems
Combustion air
Reverse draft principles
Creosote problems
Chimney construction and cleaning
Chimney fires
Ash disposal
Installation of smoke alarms and fire extinguishers
Heat reclaimers
Hazards of coal and charcoal gases
Protection of children from heating applicances

It was stressed with residents that wood is not a conservation measure, but an alternative fuel source which needs to be used wisely, and in conjunction with conservation measures such as insulating, caulking and weatherstripping. After the consultation, which took between forty-five minutes and two hours, a report was written, stressing the pertinent concerns, and was mailed to the resident along with general safety information. Though a copy of the report was kept on file, it was available only to the resident.

Besides individual consultations, information was disseminated to the public through displays at fairs and through workshops. An 80-slide show on wood stove safety was given to the program by Bob Martin. This was augmented by an additioanl 75 slides developed by the advisor. A mock-up wood stove installation complete with signs depicting critical areas and clearnances was set up at a permanent workshop site. Workshops were also offered through many community groups at various locations throughout the county. Workshops were sponsored by:

Local fire departments
Teachers' conferences
Town energy conservation committees
Fraternal organizations
Civic groups
Western Mass. Electric Co.
Monsanto Chemical Co.
New England Telephone Co.

Evaluation

As the program was reaching its conclusion, a twelve-question questionnaire was developed to determine the satisfaction of the residents serviced (Kates-Moylan, 1979). One-hundred and ninety-five people were polled; 36% responded. When asked if they had made any improvements in their wood stove installation,

43% of the respondents answered "yes"
39% of the respondents were making improvements when they received the questionnaire
20% answered "no"
5% of the applicants said the question did not apply

If no improvements were made on the wood stove installation, these were the reasons given by the respondents:

2% believed there were no recommendations made for improvements
2% believed that the improvements suggested would be too expensive
0% could not get materials
0% did not agree with recommendations made in the report
5% had no time available to make improvements

The following items are the specific recommendations which respondents made:

18% to move stove to 36" from combustible wall or no closer than 12" from a protective wall with a 1" air space
15" to move stove pipe 18" from a combustible wall or ceiling or no closer than 12" from a protective wall with a 1" air space
25% to add a protective wall
14% to extend hearth to be 18" in front and back and 6"-12" on the sides
41% to add screws to the stove pipe
14% to clean chimney
14% to have a mason inspect the chimney
23% to install smoke alarms
23% to install fire extinguishers
32% to make improvements (i.e., to arrange pipe for more efficient heating, to install new pipe or chimney, to add more protective sheeting)

Eleven percent of the respondents did not respond to this question. When asked what safety precautions were taken as a result of the analysis of the wood stove installation, respondents answered with the following:

34% made the improvements within two weeks after receiving the report
12% made the improvements within one month after receiving the report
9% made the improvements within two months after receiving the report
18% made the improvements within three months after receiving the report
27% found this question not appliable to their situation

The overwhelming response of those polled believed the wood stove advisory service to be a valuable program. This program was funded between June, 1978 and December, 1979 by a grant of $17,500 through the Comprehensive Employment & Training Act.

Conclusion
To summarize, strategies which enabled the program to succeed were:

- establishing collaborative working relationships and trust where the potential for competition existed;
- providing unbiased and confidential information to protect the privacy of residents in their homes; and
- enlisting the expertise of businesses, agencies, local governments and community groups to provide information and materials to both the residents and advisor.

These strategies can be adapted to more far reaching community outreach programs to optimize success.

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19.9

ENERGY AND ENVIRONMENT — THE DYNAMIC DUO

Dianna E. Ullery

"If it is true that we are in a permanent or even a temporary energy crisis then one of the answers must lie in public education. And I mean education not only about home insulation, speed limits or alternative power sources, but also education which enables people to find gratification without getting on a highway or a runway to achieve it."

David Rockafeller, Jr.

Certainly there can be doubt now about the existence of an energy crisis and its enduring potential. Tremendous efforts have gone into educating people to this fact and those efforts have had an impact. In 1978, most of America's young adults recognized that there was a real energy problem. However, as a consultant for the National Assessment of Energy Awareness Among Young People, John Fowler noted, "While sensitized to the realities of the energy problem, young adults show little understanding of the trade offs, time lags in energy production, conversion processes and the technologies asociated with energy development."[1] The first step in solving a problem is nurturing an awareness, but the end result has to be the development of decision making abilities. And there are some heavy duty decisions to be made.

One of our principle tasks as educators is to equip young people to successfully live in this world. Kenneth Baulding has said, "What formal education has to do is to produce people who are fit to be inhabitants of the planet." He noted that this has become urgently necessary because we have reached the boundaries of our earth and found it to be rather small. "This generation of young people has to be prepared to live in a very small and crowded spaceship. Otherwise they are going to get a terrible shock when they discover that we have taught them to live in a world that is long gone."[2]

Energy education is not an isolated topic which can be addressed within a twenty minute period once a week. As with so many other things in this world, energy is linked to everything else. The National Audubon Society, through a comprehensive energy plan, teacher workshops, educational programs and demonstration of practical technologies is conveying the message that energy development, production, use, and the quality of our environment are intimately and inextricably related.

There are those who would challenge the logic of a conservation organization being so deeply involved in energy policy development, education and research. Russel W. Peterson, President of the National Audubon Society, formerly head of the Office of Technology Assessment, Chairman of the Council on Environmental Quality and Chairman of the Advisory Committee of the Solar Energy Research Institute, responds to the challenge in this way. "One of the most important lessons we have learned in our 75 years of working to protect wildlife and wildlife habitats is that we simply cannot isolate the animals and birds of the earth — or ourselves — from the world around us. In order to preserve the variety of life that inhabits our planet, the National Audubon Society must seek to safeguard the entire network of natural support systems — the air water and land — on which all living creatures depend. And nothing has had a stronger impact on those systems than the production and use of energy."[3]

Ernest L. Boyer has linked energy education and the environment in at least three ways. First, the country's schools and colleges are major consumers of energy and contributors to the problems; education trains individuals with the technical know-how to enter new careers in environmental and energy related fields. In addition, schools and colleges must confront the realities of the next century by focusing on perspectives and attitudes that will be critical to survival. These realities include the fact that "we must learn to live like civilized beings within the restraints of nature - restraints which can no longer be ignored with impunity."[4]

An environmental approach to energy education has great potential for impacting young people in particular. Such an approach should be regarded as an effective alternative or addition to energy education based on economic incentives. This option is important for several reasons. First, young people who are not paying the utility bills have difficulty comprehending the need for conservation on their parts. Are they really willing to make a commitment to energy conservation or life style changes to save their parents money? Many young people, like their parents, refuse to accept an inevitably different future than they had imagined. In response to a scenerio in which gasoline is $3.00 per gallon, many simply determine to get a job that pays a lot of money. Young children are brand new to the environmental message since they were not here for Earth Day and the great environmental awakening. This message is a powerful one which can lead to many more options and choices for all of us.

Second, presenting a strictly enconomic rationale also makes it difficult for young people to develop a sense of personal responsibility and an understanding that their actions go beyond themselves. As many energy experts have noted, our problem is not so much a shortage of energy as a demand that will not be satisfied. Confronted with predictions of a future with infinite energy resources, Wendell Berry reminds us that, "the length of our vision is our moral boundary...By our abuse of our finite resources our lives and all life are already in danger. What might we bring into danger by the abuse of 'infinite' resources?"[5] Our responsibility as stewards of this earth does not end with the protection of its water, soil, air and wild creatures. Our wastefulness in the use of earth's physical resources to produce energy is small in comparision with the waste of human resources and energy.

Finally, it is important to provide an alternative perspective when a large percentage of the available energy education materials and information are presented by the energy industry and those who have an economic interest in the development and production of energy. Neidermeyer and Roberson stress that in reviewing energy education materials educators should, "Look for materials that present various sides of energy issues as fairly as possible and include all energy sources, as opposed to only one or two in which a particular energy source is stressed."[6]

The Aullwood Audubon Center and Farm, an educational facility of the National Audubon Society, offers a series of energy education workshops throughout the state of Ohio. The workshops, funded by the George Gund foundation of Cleveland, Ohio, have attracted a diverse group of participants including teachers, administrators, environmental educators and utility company personnel. The workshops provide a basic and broad-based foundation of energy information, hands-on activities for the classroom and opportunities to become familiar with educational resources as well as to share concerns and questions with other educators. At the same time, participants are introduced to an environmental approach to energy education.

The "Audubon Energy Plan" is another educational tool aimed at an audience of politicians, citizens and business people. Dr. Jan Beyea, Audubon's Senior Energy Scientist and a former member of the research staff of Princeton Uniersity's Center for Energy and Environmental Studies, notes that the debate is narrowing to two extremes. While there is always a point where we have to make decision, to give something up, it is not an either-or situation. The Audubon plan spells out an alternative to an either-or policy.[7] "Audubon is convinced that we can have enough energy to continue the growth of production of goods and services while at the same time protecting the enviroment."[8]

Energy is a complex and abstract idea. Education needs to fill the gap between the too simplistic definitions and the scientific jargon, between nature and technology, between the extremes of all or nothing. Energy and the environment are not the only problems that are so interconnected, but they fit together like two pieces of the same large and complex puzzle. On this spaceship earth we are not just along for the ride. We cannot act without living with the consequences. Gerry Carr, crewmember of Skylab 4 and fellow traveler on planet earth, shares his unique perspective: "I would look a the earth's horizon and see the earth's atmosphere. It is very beautiful. It is blue and white and gold and orange. And it is so thin and fragile. That atmosphere is all that keeps the earth habitable, but it's no thicker than the skin of an orange - no, thinner than that, like the skin on an apple. There's no way to explain how clearly you can see the fragility of the earth. You have to have been there."[9]

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19.10

ENERGY-SAVING LIFESTYLES

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Abstract
The residential sector directly consumes about twenty percent of the total United States energy. However, the consumer is the ultimate user of a very large portion of the energy used by the commercial, industrial, and transportation sectors of the nation. The private sector also has a good potential to reduce energy consumption through conservation. Consumers frequently equate conservation with sacrifice and saving energy with large investments. Relatively simple adjustments and retrofits in space conditioning, water heating, lighting, appliance management, and personal dress can reduce energy consumption and eliminate waste without great expenditure or a reduction in the style of living.

Heating and Cooling
For each dollar spent for energy in the home, approximately 60¢ goes for space conditioning, 18¢ for water heating, 11¢ for lighting and 11¢ for appliance operation.[1] Because heating and cooling use the most energy, we have a greater opportunity for saving in this area. Equipment should be carefully maintained for efficient operation. Filters should be checked monthly and replaced as needed to provide maximum air-flow. The home owner can purchase a supply of filters and replace them as needed more frequently and at lower cost than if done by a service person.

The least expensive way to save on heating and cooling is with the thermostat. In winter it should be set on 68 degrees and in summer a setting of 80 degrees is appropriate. If the home is to be unoccupied for several hours, the thermostat should be set six to ten degrees lower or higher depending on the season. Conditioning a smaller space costs less. Reduce the amount of space to be heated or cooled by closing off unused rooms, closets, and storage areas.

Take advantage of free heating/cooling by using the sun and shade. Roof overhangs and covered porches can create shade to effectively reduce the cooling load. Deciduous trees on the south and west sides of a building have the advantage of creating shade in the summer and in winter, when they lose their leaves, they allow the sun to shine through to provide heat. Climbing plants, such as honeysuckle or morning glories can provide shade while you are waiting for trees to grow. Light filtering through leaves is aesthetically pleasing. Outside shading is more effective than inside shading because once the sun has penetrated the window, heat builds up between the window and draperies in combination with exterior shading can be very effective in reducing heat gain.

Windows can have a considerable effect on heat loss in winter and heat gain in summer. A single pane of window glass has an approximate R-value of one. This means, if there is one degree difference between the inside and outside temperature, heat will be transmitted from the warmer area to the cooler area.[2] Storm windows or insulated (double glazed) windows will reduce heat loss by trapping a layer of insulating air between the panes. Window treatments can help keep the heated air inside on cold days. Air, trapped between draperies and the glass, serves as insulation. The insulating effect of draperies can be improved by layers or linings. Draperies are usually mounted about three inches from the wall—the perfect distance for air circulation. Due to the fact that heat rises and most homes have the heat outlets in the ceiling, warm air goes behind the drapery against the cold glass. The air cools as it travels downward and returns to the room at the bottom of the drapery. A closed top cornice won't allow the warm air to go behind the drapery, creating a buffer zone between the warmer room air and the cold window. A window quilt will add an extra layer and trap insulating air between the quilt and the window. There are many manufactured window treatments which insulate windows—good fitting roller shades are effective. Management of draperies can aid in heating and cooling. During the winter, keep curtains closed on overcast days and especially at night. Open curtains/draperies when the sun can shine in to take advantage of free solar heat. In summer, keep windows covered during the hottest hours of the day. Uncover and open windows after sunset to take advantage of cooler night air.

Air leakage, known as "infiltration," brings in unwanted air which must be heated or cooled. Infiltration accounts for twenty to forty percent of the utility bill.[3] Infiltration can occur wherever two different materials or parts of the house meet. Caulking and weatherstripping are cost effective for reducing infiltration because the materials are inexpensive and installation can be done by the home owner using simple tools. Caulking is used to control infiltration at fixed seams such as around window frames. Weatherstripping is generally used to stop air leakage at movable joints such as around doors. Wall outlets account for about twenty percent of escaped heat through air leakage. Heated air goes out through the hole behind the plate, travels up the wall into the attic, and escapes through the roof. Installation of gaskets behind outlet plugs and switch plates will reduce heat loss. Gaskets for this purpose are available at building supply stores. Enough for an average home will cost less than $5.00. To avoid overbuying, count the number of plugs and switches in your home before you purchase. Or gaskets can be made from foam or other suitable material using the cover plate as a pattern. The range hood provides another path for infiltration. Plastic wrap or foil serves as a good temporary cover for the vent to reduce heat loss. Of course, one must remember to remove the cover when the vent is used.

Use of color can make spaces appear either warmer or cooler. Warm colors (shades of red, orange, gold, yellow) add psychological warmth to a room. Cool colors (blue, green, violet) make a room seem cooler. Consider using warm color schemes for rooms with a northern exposure and cool colors for rooms with a southern or western exporure.[4]

Water Heating
Although water is not energy, it too is a precious commodity. A hot water drip is a double waste. Not only is the water lost, but the energy required to heat the water is wasted. The second largest energy expenditure in the home is for heating water. Aside from stopping leaks, the place to start saving water heating costs is at the water heater. The thermostat should be at the lowest possible setting to provide adequate hot water. For best results, a dishwasher needs water at about 140°F. If the home does not have a dishwasher, a lower water heater setting will be more practical. The human body can tolerate water to 110°F. Thus, it is wastful to heat water so that it must be cooled for use. Frequently the water heater thermostat must be set higher to achieve the correct temperature at point of use because water traveling through a bare line loses one degree per foot. Insulating hot water lines will minimize this heat loss. Super-insulating the water

heater tank will help keep the heat in the water. Insulation jackets are available at building supply stores for about $15.00. Installation is simple, one person can do it in about fifteen minutes. Use care when insulating a gas water heater to allow for proper ventilation. A portion of the blanket should be cut away to allow air to get to the burner.

Other ways to reduce water waste include maintenance of the commode to prevent leaks and overfilling. The amount of water the commode uses can be reduced without hampering operation by displacing part of the tank water with a brick or filled plastic bottles. Flow restrictors in shower heads and sink faucets can reduce the flow by fifty percent without affecting pressure. Showers should be limited to less than five minutes. Make a habit of turning on cold water when you want a small amount of water and don't allow water to run continuously for tasks such as brushing teeth. Laundry accounts for a major portion of hot water consumption. This can be minimized by washing clothing with warm rather than hot water and rinsing with cold; washing complete loads instead of one or two articles; and matching the water level to the size of load.

Lighting

Home lighting can account for savings with almost no investment. Turning off lights does save energy. Condition family members to turn off unnecessary lights. Another way to reduce energy usage with lighting includes: the use of lower wattage bulbs. Sustitute sixty watt or smaller bulbs for large wattage bulbs in hallways, closets, and other areas where bright lights are not necessary. Where a lot of light is needed, one higher wattage bulb will give more light for the energy used than numerous smaller ones. For example: one 100 watt bulb produces almost the same amount of light as two 60 watt bulbs, yet uses twenty percent less energy. Never use a higher wattage bulb than specified for a fixture—it could cause a fire—and it shortens the life of the bulb. Longlife bulbs may last longer but produce twenty percent less light, so are not energy efficient; use them only in areas where it is very difficult to replace bulbs. Reduce the number of bulbs in multi-bulb fixtures. For safety, don't leave live sockets empty; fill them with burned out bulbs.

Fluorescent lights are more efficient than incandescent light and last longer, too. Companies manufacturing light bulbs are making fluorescent bulbs and other energy saving types which will fit standard sockets. These should be available within 1981. All light bulbs, reflectors, shades and chimneys should be kept shining clean. Dust and dirt absorb light and lower lighting efficiency as much a s fifty percent. Decorating can reduce the need for lighting. Light colors relect light, dark colors absorb it. Consider painting ceilings a lighter color than walls to reflect light.

Appliances

Appliances, a boom to housework, use energy too. How we manage their use affects the amount of energy consumed. The first step in saving appliance energy is to turn them off when not in use. Keep all equipment clean and well lubricated to reduce friction and lower energy consumption.

Specific appliances offer opportunities for energy saving. The dust bag of the vacuum cleaner should be emptied frequently to enable the machine to do its job easier. The lint screen of the clothes dryer should be clearned after *every* load. Clothing should be removed from dryer while slightly damp. Over-drying damages the fabric as well as wasting energy. Air dry clothing when practical. Personal appliances such as hair dryers and curling irons should be preheated a minimum time. Towel-dry hair as much as possible before using the electric dryer. Turn appliances off immediately after use.

The condenser coils on refrigeration units should be vacuumed frequently. Dirt and dust inhibit heat exchange and cause the equipment to operate longer. Manuel defrost refrigerators and freezers use less energy than automatic ones. They should be defrosted frequently to prevent frost from building up more than one-fourth inch. Doors on units should close properly and gaskets should form a snug seal.

The dishwasher should be used with a full load. Use the energy-saver feature if available; if not, stop the dishwasher after the final rinse and allow dishes to air dry.

Food Preparation

Save energy during food preparation by using the correct size pan for the burner and cover pan to reduce heat loss. Avoid using the range oven for just one item; instead, cook a complete meal in the oven or prepare a double recipe and freeze half for another meal. Use the oven at a time of the day when heat will be beneficial rather than add to the cooling load. While using the oven DON'T PEEK. Set a timer. Every time the oven door is opened the temperature inside is lowered by about fifty degrees, which the oven then has to heat again. By planning ahead, frozen foods can defrost in the refrigerator. The refrigerator can use the cold and less energy will be needed to cook thawed food.

Small appliances usually consumer less energy than range units. A microwave oven too uses less energy than a conventional oven because all the energy produced is absorbed by the food. Serving some foods raw provides variety and eliminates the cost of cooking. Use the barbeque grill or build a solar cooker to prepare meals out of doors for summer fun and to avoid heat build-up in the kitchen.

Clothing

A little personal weatherization will reduce the amount of energy-consuming heating and cooling needed. Appropriate clothing can greatly improve comfort in a wise range of weather conditions. During hot weather use lightweight, loose-fitting garments to allow release of body heat. Natural fibers are more absorbent than synthetics and will help carry perspiration away from the body.

Cold weather clothing reduces loss of body heat by trapping a layer of air next to the skin. By adding layers of clothing more air is trapped, keeping the body warmer. Reduce heat loss by wearing garments with belts and drawstrings, ribbed cuffs at wrists and ankles, hoods, and turtlenecks. Long underwear and pants liners help too. By wearing shirts, blouses, sweaters and jackets in varying combinations, it is easy to match the amount of clothing to the surrounding temperature by adding or subtracting layers.

Footnotes

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19.11

A COMPARISON OF HOME HEATING AND COOLING COSTS USING VARIOUS SYSTEMS

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Abstract
Space heating and cooling account for 50-60 percent of all energy used in the home. Rising energy costs, due to the dwindling supply of petroleum, have become a major concern for today's familes. This paper compares the cost of heating a home in West Texas by natural gas furnance, heat pump, and electrical resistance heat. The cost of cooling is compared for electric resistance heat. The cost of cooling is compared for electric refrigeration air-conditioning evaporative cooling, heat pump, and gas air-conditioning. Energy consumption and cost comparisons are summarized in Table I.

The Home and Occupants
The 14 x 80 unit contains 1,120 square feet. The walls, attic, and floor are insulated with 3-½ inch batts of fiberglass insulation. Exterior siding is one-half inch masonite. Interior walls were covered with gypsum board prior to paneling. The composite R-value of the walls is 12.5. The floor has an R-value of approximately 13.5 because of the insulating factor of carpet and padding in the living room and bedrooms. The house sits on block risers sixteen inches above ground. The crawlspace is tightly skirted with siding material and vented at both ends of the house. The roof has a sixteen inch gable which creates a small attic. Asphalt shingles cover the three-fourths inch plywood roof. The interior ceiling is made of acoustical tile. These materials create an approximate 13.5 R-value.

Window area equals twelve percent of floor space. The house is fitted with storm windows and storm doors. Windows on the west side are shaded in the summer by deciduous trees. During winter months, the sun can shine through the bare trees and help heat the house. Occupants normally open curtains on sunny winter days to allow for solar penetration. To reduce cooling costs, occupants turn off the air-conditioner and open windows and doors on cool summer days and at night. Draperies are closed to minimize solar gain during the hottest part of the day.

The home is occupied by two persons, an adult female and her teenage son. They are away from home during each weekday. During winter months the thermostat is kept at 70 degrees; in summer months the thermostat is set on 82 degrees. When residents are to be away from home for several hours, they lower the thermostat setting six degrees in winter and raise the setting six degrees in summer.

Cooling System Comparisons

Refrigeration Air-Conditioning
The home is cooled by a 2-½-ton electric refrigeration central air-conditioning system. The compressor unit is located outside the house. The same fan and duct system is used to distribute heated air in winter and cooled air in summer. Electrical consumption by the cooling system is shown in Table II.

The base consumption was derived from months when electrical consumption was lowest (e.g., March, April, 1979; May, November, 1980), when electricity was used for activities which are conducted year-round such as cooking, water heating, appliance operation, and lighting. Almost no heating or cooling would have been used during these months. The base consumption of 550 kilowatt-hours (kw-hr) per month was subtracted from the actual monthly consumption; the difference during summer months can be attributed to cooling. The system used a total of 3056 kw-hr to cool the home during the 1980 cooling season at a cost of $152.80, based on an average cost of $.05 per kw-hr.

Heat Pump
A 2-½-ton heat pump was recommended for this specific house.[1] When providing cooling, the heat pump operates as a refrigeration air-conditioning unit. Thus operation costs would have been equal for the two systems ($152.80). For an *exact* comparison, the energy efficiency ratio of each system must be considered.

Evaporative Cooling
Evaporative cooling is an efficient means of air-conditioning and increasing humidity in arid areas such as the Texas Plains. Cost of electricity for evaporative cooling would have been approximately $64.16. The ½ horsepower (hp) motor and ¹/6 hp pump would have consumed 1283 kw-hr in 1,470 hours of operation. The average annual cooling hours for the Lubbock area is 1.350. Because of the unusually hot summer of 1980 and the homeowner's schedule, extra cooling hours have been estimated.[2] This calculation does not include the cost of water. At present there is no data on the amount of water used by evaporative cooling. The amount used would depend on the relative humidity of the outside air, the condition of the wicking pads, and whether the pump kept the pads saturated. Water is included in the rent and since the water comes from a private well, there is no measure of water consumption.

Gas Air-Conditioning
A three-ton unit is the closest size adequate for cooling the home. In 1,470 cooling hours, the unit would consume 107 thousand cubic feet (MCF) of natural gas at $3.75 per MCF and 1.176 kw-hr of electricity at $.05 per kw-hr at a cost of $406.55 for the season.[3]

Heating System Comparisons

Gas Fired Furnance
The home is heated by an 80,000 British thermal units (Btu) natural gas fired forced air furnace. An electric motor is used to power a fan which distributes the heated air throughout the house. The electrical consumption used for air circulation has not been calculated because of the difficulty of isolating this consumption from other possible winter electrical usages. This cost would be incurred for all heating systems and would likely be a similar amount.

Table III shows that 47 MCF were used for the 1979-80 heating seasons, costing $142.49. The 47 MCF produced 48,410,000 Btu of which approximately 75% (36,307,500) heated the home. The remaining 25% are lost due to the necessary exhausting of the furnace. The pilot light consumes about 10% but will be considered as part of heating because the heat generated by the pilot contributes to the heat in the home. Seventy-five percent of the Btu will be used for cost comparisons with other systems.

Electric Resistance Heat

An electric resistance furnace operates very simply. A resistance element gets hot when electricity passes through it. Air is forced ove rthe heated element, the heated air then is distributed into the living space. Electric resistance heat produces one unit of energy for each unit of electricity or 3,413 Btu per kw-hr.[4] During the '79-'80 season, 10,638 kw-hr would have been needed to produce 36,307,500 Btu to heat the home at a cost of $531.90.

Heating with a Heat Pump

Generally a heat pump uses electrical energy only to run the fan and compressor. Even cool air contains some heat. The heat pump absorbs heat from outside air, concentrates the heat and transfers it into the home. The efficiency of a heat pump varies significantly with the outdoor temperature. In this geographic area, a heat pump will produce 2.5 units of heat for each unit of energy consumed; therefore, a heat pump will produce 8632.5 Btu for each kilowatt hour used.[5] When the outside temperature drops below 35 degrees F., the heat pump must be supplemented by another heating system, such as electric resistance heating. The disadvantage of the heat pump is that it is most inefficient when heat is most needed and heat pumps are now supplemented by electric resistance, the most expensive form of heat. Heat pumps with natural gas fired auxiliary heat are expected to be available by 1985. To heat the home with a heat pump would have required 4,206 Kw-hr to produce the needed 36,307,500 Btu or $210.30, seasonal heating cost.

Conclusions

Based on current costs of energy, natural gas heating and evaporative cooling are the most economical methods. If the cost increases for electricity and natural gas remain parallel, natural gas will still be the least expensive. As long as natural gas is used to generate electricity, the costs will remain relatively parallel. However, with alternate sources of energy for the generation of electricity such as coal, solar, nuclear coupled with the decreasing supply of natural gas, these cost curves may take different directions.

If the sale of natural gas is deregulated, some project that the price will triple. If this were to occur and the cost of electricity were to remain the same, the electric heat pump would be a cost competitive alternative. A heat pump with natural gas auxiliary heating when temperatures are too low for the heat pump to heat the dwelling, will become cost competitive much sooner. The initial investment compared to other furnaces causes a longer payback period. As more heat pumps are produced and the technology refined, the initial cost for a system may decrease, or even more likely, the initial cost of other systems may increase causing a "relative" decrease in the cost of heat pumps.

Gas furnaces are now available with electronic ignition which eliminates the pilot light. Pilot lights consume about 10% of the total fuel used for a furnace. During the heating season the pilot light is of little concern because the heat generated can also be used. During summer months, the extra heat adds to the cooling load. An electronic ignition could be added to an existing furnace at a cost of $150. However, this would create a hybrid system that neither the original manufacturer nor anyone else would guarantee. Based on the current cost of natural gas, the payback period in gas savings would be over 10 years. Turning off the pilot light during the cooling season; and re-lighting the furnace when heat is needed in the fall is a very minor inconvenience.

Other things that could be done to make this home more energy efficient include:

1. Attic ventilation-soffit and gable vents could be installed relatively easily which would reduce the cooling load.

2. Improved window treatments-layered draperies, heavier fabrics, and closed top cornice swould reduce the heat transfer of the windows.

3. A vapor barrier against the ground under the house and insulation just inside the skirting would reduce heat loss through floors and increase comfort.

4. Added insulation in the attaic would help. Due to construction, the insulation would need to be blown in. Six-inch fiberglass equal to R-13 would make the total R-value for ceiling and roof R-26, the recommended amount for homes in Texas. Due to the size of the attic a person cannot enter it, so installing the insulation would be difficult to control. Holes would have to be cut into the ceiling or roof to gain access. The added insulation would literally fill the attic allowing very little space for air circulation necessary for ventilation.

5. Extruded styrofoam sheathing could be installed in the walls by removing the exterior siding, installing sheathing and replacing the siding. This would add R-3.75 to the present 12.5. The major constraint is cost of the materials and the risk of damaging the Masonite siding as it is being removed.

6. A programmable thermostat would allow the occupants to schedule thermostat settings based on anticipated heating and cooling needs. This could result in some savings because occupants sometimes forget to adjust the thermostat before leaving. The thermostat could be programmed for a much lower setting during the middle of the night with resumed heating by the time residents arise in the morning.

7. Ideally, the orientation of the house should be changed 90 degrees. Presently, it sits with long sides to the east and west. If the house were rotated so that long sides faced south and north, the afternoon summer sun would not strike the broad side which now adds to the cooling load. A south-north orientation would facilitate the absorption of winter sun and reduce the heating load. Cooling load would also be reduced because the summer sun would strike the roof rather than the walls and windows.

A solar greenhouse could be attached to the long south wall which would provide at least half of the heating through use of passive solar collection. A greenhouse would not aid cooling as much as it would shade the southern exposure of the house and eliminate sun penetration and reduce heat build up.

A house moving company in Lubbock estimated the cost of rotating the house at $800. The skirting would have to be removed and footings prepared for re-setting the house. Some plumbing would be required. Total cost of rotating the house would range from $1,000 to

$1.500. If a southerly orientation and greenhouse could possibly reduce energy costs by 50%, the payback period for the rotation alone would be 10 years. Cost of construction of the greenhouse is estimated at $1,300-$1,500, which would double the payback period.

The most economically feasible alterations to the house are improved window treatments and installation of attic vents. Other energy saving measures could be implemented when income permits and when the tax credits would be beneficial. Tax credit would probably not be allowed for changing the orientation unless careful documentation of energy consumption could prove savings due to change in orientation. However, if the house is ever moved to another location, it should definitely be oriented for best southern exposure.

Occupants can minimize energy costs by careful management of energy usage. Poor management and waste can eliminate any savings from investments.

TABLE I

A COMPARISON OF HEATING AND COOLING COSTS FOR AN 1,120 SQUARE FOOT HOME USING VARIOUS SYSTEMS

Type of Unit	*Initital Cost of System*	*Units of Energy Consumed*	*Cost for Season*
Heating			
Natural Gas Furnace	$ 450	47 MCF*	$142.49*
Electric Resistance Furnace	375	10,638 kw-hr	531.90
Heat Pump	2,200-2,400	4,206 kw-hr	210.30
Cooling			
Heat Pump	same unit as above	3,056 kw-hr	152.80
Electric Refrigeration	450	3,056 kw-hr	152.80*
Evaporative Cooler	450-500	1,283 kw-hr*	64.14
Natural Gas	2,100	107 MCF 1,176 kw-hr	347.75 58.80 $406.55

*Actual consumption and cost: other figures are calculated estimates. Calculations are based on an average cost of 5¢ per kw-hr (kilowatt hour of electricity), and $3.25 MCF (1,000 cubic feet of natural gas).

TABLE II

ELECTRICAL CONSUMPTION BY REFRIGERATION AIR-CONDITIONING FOR SUMMER 1980

Month	*Consumption kw-hr*	*kw-hr Used for Air-Conditioning*
June	*1150*	*600*
July	*1505*	*955*
August	*1572*	*1022*
September	*968*	*418*
October	*611*	*61*
	Total	3056

TABLE III

NATURAL GAS CONSUMPTION FOR 1979-80 HEATING SEASON

Month	*MCF*	*Cost*
October	2	$ 7.12
November	8	23.47
December	10	29.24
January	9	26.92
February	12	35.23
March	5	16.02
April	1	4.49
Total	47	$142.49

Footnotes

[1] R. Jarnagen, Consuer Service Representative, Southwestern Public Service Company, Lubbock, Texas, February, 1981.

[2] L.J. McNeil, P.E. Texas Engineering Extension Service, Lubbock, Texas, February, 1981.

[3] J. Smith, Engineer, Fields and Company, Lubbock, Texas, and B. Brewer, Engineer, Pioneer Natural Gas, Lubbock, Texas, provided data on gas air conditioning.

[4] R. Jarnagen, Consumer Service Representative, Southwestern Public Service Company, Lubbock, Texas, February, 1981.

[5] Ibid.

SESSION 20: ENERGY EDUCATION INFORMATION — RESOURCES AND COOPERATION

20.1

PARTNERSHIPS IN ENERGY EDUCATION: LOOK AT MODEL EFFORTS IN COORDINATION AMONG INDUSTRY, EDUCATION, AND GOVERNMENT

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Introduction

Supporters and innovators of energy education will face some of their greatest challenges during the 80's. Efforts to elevate public awareness of the need for energy education have succeeded. Educators, public officials, industry leaders, and consumer groups are seeking opportunities to contribute resources and time to this end. Some search for good materials to purchase and distribute while others develop curriculum packages. Some offer programs, films, facility tours, and media programs. Others seek out speakers, courses, and energy events to attend. The variety and number of educational opportunities have been escalating, yet available funding resources are diminishing. These two fundamental conditions constitute the major challenge for energy educators: to undertake the most beneficial, cost-effective ways to coordinate and manage diversified energy education efforts at the local, state, regional, or national levels.

Energy educators are now trying to determine how energy education programs can compete for both money and space in the school curriculum. What will happen to materials previously developed with public funds if there are no more dollars available for printing and revisions? What kind of teacher education will be available without adequate funds for in-service programs, college seminars, and courses? Will there be technical assistance available for school districts that want to develop an energy education program?

The move by the federal government toward providing States with block grants for education will pose a challenge for those seeking answers to those questions. In a recent book published by the Brookings Institution, *Setting National Priorities: The 1982 Budget*, David W. Breneman explains that block grants will increase "state and local autonomy in spending federal dollars" and that both the "state and local education agencies would value increased control"[1] over the allocation of those funds. Under such grants, the education agencies will necessarily have to determine their own educational priorities. If expanded energy education programming is one of those priorities, energy educators have no problem. If not, then what are the alternatives?

If energy educators can no longer legitimately depend upon federal and state monies to support energy education programs, then responsible, new collaborative efforts will be required. Donald W. McCurdy, National Science Teachers Association (NSTA) president - 1980-81, cites the need for members "to explore new and creative ways of cooperating with other professional organizations to facilitate common goals."[2] Just as coordination of efforts is suggested by Mr. McCurdy among professional groups, U.S. Secretary of Energy, James Burrows Edwards, has fostered this partnership concept by stating that "a major aim of the new DOE is to establish more appropriate roles of government and the energy industry." He suggests that the responsible operation of government and industry serves "as an instrument of progress and social betterment."[3]

Prevailing economics and political conditions continue to reinforce the need for a positive association among educators, government, and industry to meet educational and community needs. The common bond in this partnership relationship is a commitment to those served: school children, teachers, administrators, families. Virginia Knauer, Special Assistant to the President and Director of the U.S. Office of Consumer Affairs, reiterates more specifically the challenges of cooperation: "Informed consumers," she says, "can play an important role in the revitalization of our economy and we will work to support their partnerships with business and government."[4] A former Pennsylvania Power & Light Company Board of Directors member, Mrs. Knauer reflects the broad view of cooperative efforts that are supported not only by PP&L but by all major investor-owned utility companies in Pennsylvania.

Echoed in the statements here is the message that fostering energy education cannot be done alone. The task requires cooperation. The economics and management of the multitude of energy education programs already underway make cooperation necessary. The possibilities of exciting and enlightening results which demonstrate an impact on the energy situation are increased by cooperation. Consequently, partnerships among education, industry, and government promise to be the most effective way to meet essential energy education objectives.

From a concept of partnership there must evolve a process for implementation. How does a city or county, region or state develop a mechanism and a climate for education, government, and industry cooperation? The methods may vary considerably based upon the resources available to the organization which will take the initiative and the responsibility to serve as the catalyst.

The experiences of Pennsylvania Power & Light Company (PP&L) will serve here as a model for the readers's consideration. Uniquely, PP&L has formed two local partnerships, coordination an effort among the other major investor-owned utilities in Pennsylvania, and aided in the development of a diverse statewide partnership, all focusing specifically on energy education.

Energy Education Advisory Councils

In 1979, PP&L took steps to broaden its association with educators, recognizing that, in order to contribute to the energy literacy of future generations, the company needed educator assistance. The approach taken was the formation of an Energy Education Advisory Council

(EEAC) in one of the company's six operating divisions (Lehigh Division). This twenty-three member council was composed of teachers, students, administrators, college and agency representatives. As a pilot effort, the Lehigh Energy Education Advisory Council (LEEAC) was charged with working cooperatively with two PP&L staff members (both former teachers) to develop and test an instructional unit on energy. LEEAC was given complete freedom to select topics and grade levels, approach and format. PP&L committed only funds, technical resources (when requested), and staff support. The content of the unit was the sole responsibility of LEEAC members. However, PP&L reserved the right to make final decisions whether or not to publish and disseminate the materials based upon an assessment of the value and accuracy of the end product.

This pilot activity required the unfaltering commitment of each LEEAC member over the eight months needed to complete the pilot phase. An eleven-lesson curriculum package, "Energy Conservation in Our Homes Or, How I'm Going to Help Save Energy by Starting with Me!" was designed for 4th, 5th, and 6th graders, field-tested, and statistically evaluated. Data collected revealed a 30% total group improvement in energy knowledge and 12% improvement in attitudes. Teacher and student evaluation of the materials revealed that they were best suited for 5th graders by virtue of thematic appeal. Some data was also collected on parent involvement in the process.

In all, the project was an overwhelming success. It yielded some significant findings:

1. Educators and a utility company can enter into a meaningful partnership to meet mutually important needs.

2. Cooperative efforts develop mutual trust and respect, are cost effective, and provide meaningful results.

3. Effective energy education makes a real impact on students, teachers, and families.

Based upon these realizations, PP&L's senior management approved continuation of the efforts of LEEAC. With equal enthusiasm this group is proceeding with a 6th grade unit which follows in scope and sequence from a K-12 energy education continuum previously prepared by the Council. In addition a second EEAC has been formed in PP&L's Harrisburg Division to develop interdisciplinary units for the secondary grades.

The successes and personal rewards of the EEAC's within the PP&L service territory reaffirm the value of coordination. In May 1981 Susan M. Shanaman, Chairman - Pennsylvania Public Utility Commission, praised those Pennsylvania electric utilities who have "taken the initiative to establish working energy education advisory councils to develop energy-related curriculum for local schools." She charged that this "forward movement must continue."[5] As a way of broadening the impact of energy education in Pennsylvania, PP&L took the initiative to facilitate some statewide coordination as well.

Pennsylvania Electric Association Special Committee on Energy Education
Recognizing the need to coordinate energy education among the investor-owned utilities, PP&L initiated efforts in 1979 to form a Special Committee on Energy Education within the Pennsylvania Electric Association (PEA), the industry's trade association. In 1980, representatives of the seven major investor-owned utilities began to meet formally to share ideas and undertake program activities which were better done collectively. Recognizing the advantages of industry cooperation the Committee agreed to function as a catalyst for the formation of a statewide partnership which would involve a broader base of representation.

Pennsylvania Council on Energy Education
In January 1981, the PEA Special Committee on Energy Education hosted a meeting of key educators, government, and energy-industry leaders interested in the concept of a partnership in energy education. The meeting included key representatives from the Pennsylvania Department of Education, Pennsylvania Public Utility Commission, Governor's Energy Council, Pennsylvania State Education Association, Westinghouse and the major education and energy-industry associations. The result of this meeting was a consensus to begin coordination of energy education in Pennsylvania by developing a proposal to formalize a statewide partnership.

At the time of the 1981 International Conference on Energy Education, the proposal is undergoing its final revisions. After review by the executives and boards of each prospective member organization, the Council will have obtained its final endorsements and will proceed with the scheduling of the first official session, anticipated for January 1982. Once the Council is established, it will begin its mission: to provide direction, leadership, and planning for energy education in Pennsylvania through cooperative efforts among its members. Activities might range from teacher education programs, demonstration projects, resource sharing, a newsletter, and long-term planning which would provide continuity and structure to an even broader range of related activities.

PP&L and the other PEA member companies completed the preliminary planning for this effort more than two years ago. But the results seem to be near at hand. Certainly, the time is right to set into motion a systematic process for ensuring that energy education becomes integrated into all areas of school and community educational programs. These efforts require time, compromises, and commitment. They must be done with honesty, openness and integrity to ensure effectiveness.

Conclusion:
Conditions are at their best to bring the education, industry, government, and local communities together. The late sixties and early seventies were fraught with upheaval, distrust, and fragmentation. With commitment the eighties can bring a return of order, confidence, and cooperation in solving problems and meeting needs responsibly. To miss this opportunity now would be regretable. National Science Teachers Association Project Director, John M. Fowler points out that "energy education has reached new heights of visibility and effectiveness in 1981." "It is crucial", he adds, "to assess the present state of energy education, and to design a new support framework(composed of) local and private sector" groups.[6] By establishing meaningful and equitable partnerships, energy educators should be able to contribute to a heightened energy literacy in our society.

Footnotes

1 David W. Breneman in SETTING NATIONAL PRIORITIES: THE 1982 BUDGET, ed. Joseph A. Peckman *et al*, (The Brookings Institution, Washington, D.C., 1981), p. 74.

2 Donald W. McCurdy, National Science Teachers Association 1979-1980 Annual Report, (Washington, D.C., 1980), p. 6.

3 James Burrows Edwards, Energy & Education 4, 1 (April 1981).

4 Virginia Knauer, CONCERNS 3, 1 (May 1981).

5 Susan M. Shanaman, "Conservation and TMI: Two Major Concerns of the Pennsylvania Public Utility Commission," (May 5, 1981), p. 2.

6 John M. Fowler, Energy & Education 4, 3 (April 1981).

20.2

ENERGY INFORMATION -- KEEPING UP TO DATE

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Abstract
Both the information explosion and the electronic revolution are having, or soon will have, a profound effect on all aspects of world society. This is of particular importance in the area of energy education where a current awareness of up-to-date information is a prime necessity. What are the major channels for the transfer of information from the researcher to the user community? How does information feed into these channels from both national and international sources? The role of the library as an intermediary and its role in the accumulation of energy related resources is discussed. Specific emphasis is given to current information and the use of computerized data bases for fast, efficient retrieval of worldwide energy developments of interest to the education community. Examples of this electronic retrieval system will illustrate the types of information available. A view towards the future of energy information will be made with emphasis on the growing international telecommunications/computer networks in what has been called our global village.

Introduction
Over the past decade evidence has been accumulating that segments of world culture have moved beyond industrialized society into what has been called the post-industrial, or information, society.[1] There is little doubt that the United States is in the final stage of becoming an information society and other countries show signs of progress in this area as well. The existence of the information society is readily apparent in the availability of vast energy information resources. They have been collected from throughout the world and organized in both standard library collections and computerized data bases. Thus, they represent a truly international energy resource easily accessible to the entire world culture.

It is the intention of this paper to provide a general introduction to the various sources of energy information. The first section provides basic rules on how to locate information. A discussion of information resources on energy and examples of both printed and computerized data base information follow. Finally, a short scenario of the future is presented to illustrate one possible extension of the post-industrial society.

Locating Information
There are very few questions concerning energy that cannot be answered (given enough time and resources) but it is seldom that both of these quantities are available to the information seeker. Thus, it is important to know how to locate materials in an efficient manner. This is accomplished by establishing what information is needed, deciding where to look for it utilizing a logical search process, and determining when to seek help. The rules of thumb listed below, along with suggestions for their implementation, provide guidance in seeking energy information in libraries. Rule of Thumb 1 - Don't discount serendipity (also called browsing), but use it carefully.

One approach is to go through a stack of magazines or journals devoted to the general topic of interest. Another is to locate the section in the library where books on the subject are stored and use the same procedure. In both instances, a rather random search procedure is used while scanning the materials. One can also locate a general descriptive article in an encyclopedia, yearbook or other reference source and read it. All of these ways will help in understanding and defining the problem, but care must be taken not to rely on serendipity for all search activities because it often leads nowhere and provides an incomplete amount of information. Rule of Thumb 2 - The more specific the topic the easier it will be to locate the energy information.

Information on energy is a broad, all encompassing category including such topics as nuclear power, wind energy, conservation, economics, and legal matters. Energy information is a large quantity of material. Educational materials are another category, but the quantity of information is much smaller than the larger topic of energy. If a researcher is seeking educational materials on energy generated by water power, the amount of available information is reduced even further. To be more specific add qualifying terms, to be more general include fewer qualifiers. When the question has been properly framed then the process of locating information can begin. Rule of Thumb 3 - When attempting to locate energy information use a preplanned search strategy.

There are various choices necessary in planning a search strategy. The first level provides a choice between manual and computerized data base searchers. Many times the choice is dictated by the type of question and the extent of information needed. For instance if the researcher needs background information, a manual search of reference materials or the card catalog would be most appropriate. However, if the latest information on alternative fuels is needed then the Energyline or National Technical Information Service (NTIS) computerized data bases would be used. This example also illustrates the fact that often a combination of manual and computer searches could be employed to broaden the scope of information retrieved. Be aware that, while there is some overlap, many of the sources of information contain unique materials. There are various locations where information is found once the citation, or reference to specific data, is identified. Rule of Thumb 4 - Go to, or access, the formal sources set up to provide assistance for information seekers.

Libraries are equipped to provide assistance to researchers at all levels, from the simple to the complex. Not only can local collections provide help, but through information networks (called interlibrary loan) and access to computerized data bases, the resources of virtually the entire world are available. It is especially important for the researcher to know when he/she does not know where to turn and needs expert guidance. Sometimes it is necessary to have considerable persistence, but observing the rules of thumb will result in locating the desired materials. Energy information is set up in such a way that tools have been provided for access into the mass of stored information available throughout the world. The job of the researcher is to be able to ask the right question, know the major tools and rely on others to help when it is necessary to go beyond standard access points. A reference librarian can be, and often is, the best guide to the wealth of energy resources available.

Information Resources
Crowley[2] has listed over 750 United States organizations that are sources of information and publications in the energy field, many with worldwide scope. Publications of research, methods, applications, and new developments may be in the form of science journal articles, technical reports, newsletters, magazines, conference proceedings, patents, theses or dissertations. Information may also come from individuals. Research institutes, university research centers and professional or trade associations produce a great deal of information in the field. Corporations and businesses may sponsor research and produce scientific records. Government agencies accomplish and publish research on all levels, international, national, state and local. Policies, laws and regulations are being published every day throughout the world which affect the use and development of new technology.

Much of this material is stored in libraries and can be found by the rules of thumb and using subject indexes. Some of the indexes which are considered standard sources of energy information are: *Applied Science and Technology Index, Atomindex, Chemical Abstracts, Energy Abstracts for Policy Analysis, Energy Information Abstracts, Energy Research Abstracts, Energy Index, and Engineering Index.* Each index draws from a different group of journals, reports and other materials. Abstracts are often included in the indexes for further help in finding relevant material. Some of the indexes are available in computerized format and can be searched for quick results. A fee is often charged for computer searches and a bibliography is printed for the researcher. This bibliography contains the most up-to-date information available on the subject. Usually the time saved by the computer search far exceeds the monetary investment. It is even more important in using computer access to follow rules of thumb 2 and 3 to be specific and to use a prepared search strategy.

Search examples
A teacher has decided to include nuclear energy in a general science course and needs some resource material. The Three Mile Island accident comes to mind as an example of safety and environmental problems. Selecting the Educational Resources Information Center (ERIC) index to educational materials, the index lists "science curriculum" or "science education" or "energy education" as possible entries. The only index term under nuclear is "nuclear physics". A scan of the entries in the January-June 1980 index identified 31 items under science education; 16 under science curriculum and 110 under science education. Most of the titles were general. A search was then made of the computer version of ERIC which covers June, 1966-present and lists over 360,000 citations. The term "nuclear power" generated 249 citations. An additional term, curriculum, was added to make the search more specific and 113 items were located. The need to be specific. As the figure illustrates, the entire ERIC collection numbers 360,000 items. The term nuclear by itself has 1,242 citations; power, 8,799; curriculum, 57,259. But when all three are combined in a specific search question 113 remains out of the entire data base. Two of the citations are printed below.

EJ232923
Nuclear Power and the Science Curriculum.
Scott, William
Physics Education, v15 n5 p286-87 Sep 1980

EJ218550
Teaching About Nuclear Power: A Simulation.
Maxey, Phyllis F.
Social Studies Review, v19 n2 p43-46 Win 1980

When the phrase "Three Mile Island" was used in the ERIC data base, there were 12 items cited. One example is a chemistry lesson:

EJ224357
A Chemistry Lesson at Three Mile Island.
Mammano, Nicholas J.
Journal of Chemical Education, v57 n4 p286-87 Apr 1980

Wind energy sources are being utilized in many parts of the world. To find some examples of recent projects on the use of windmills to generate electricity on farms, the Keywork Index to the *Government Reports Annual Index* (NTIS) for 1980 was consulted. It listed 40 references for reports under the entry "wind power," 30 under "wind power generation," 9 under "windmills," and 11 under "windmills (wind powered machines)." Reading through these entries located one report for irrigation on a farm. The others were for different applications of wind power.

A recent article in *Popular Science*[3] discussed gasohol. To find publications which describe the work being done in the field, a search of the computerized data base Energyline was conducted. This data base contains over 29,000 entries which cover the literature from 1971 to present. The term "gasohol" retrieved 65 citations which included a bibliography and a report on farm production of fuel alcohol. The citation for the bibliography is printed below with its abstract:

130125*81-022768
Alcohol Fuels: An Annotated Bibliography, Natl Center for Appropriate Technology Report, 1980 (8)
Bibliography: Available literature related to the production of alcohol fuel through fermentation, cellulose hydrolysis, and pyrolysis is listed. The source, general content, date of publication, length, and price of each listing are presented. Books, periodicals, and access listings are included. Titles included, titles include: Makin' it on the Farm, Making Alcohol Fuel-Recipe and Procedure: Methanol and Other Ways Around the Gas Pump: Survey of Alcohol Fuel Technology; The Lore of Still Building; Learning Guide for Alcohol Fuel Production; Gasohol U.S.A. (Periodical); The Mother Earth News (Periodical); and Alcohol Fuel.

Access to this bibliography would provide the researcher with a comprehensive list of sources on various types of alcohol fuels; thus, in this instance the acquisition of the bibliography would be the next step in the information gathering process.

These examples illustrate the extent of the resources available in the energy field as well as the usefulness of computerized data bases. They also illustrate the necessity for specificity when searching large data bases on topics where a great deal of research and material has been accumulated.

Future

Certain trends in information and information technology can be identified that provide a scenario of what we can expect in the future. The continuation of the electronic revolution will result in the introduction of smaller computers and computer related components with a corresponding increase in capability for storage and manipulation. The near future promises to put micro or mini computers into the homes of a sizable proportion of the population. Home access to computer networks and conferencing by computers plus interactive Cable Antenna TV (CATV) systems will help decentralize and reshape society. The use of telecommunications via satellite will supplement, and in many cases surpass, the use of land lines as basic communication links. The use of this technology to cope with ever increasing information resources will allow great sophistication in seeking out answers to problems and producing relevant data on a subject.

For those in energy and energy education, the end result is two-fold. First, decentralization and the concomitant increase in the use of electronic technology in education will require new approaches to the learning process. Second is the ready availability of information on energy and related areas on a worldwide basis. These two will have to be combined into a new dynamic of teaching unlike anything we have yet to try. One possible scenario is the use of Selective Dissemination of Information (SDI) on a real-time basis. Those interested in keeping up to date on a certain set of topics can form questions similar to those in the examples in this paper. These questions are stored in a computer, matched against new information on a regular basis and the results transmitted to the user. By stretching the scenario a bit an entirely new picture comes into focus. Computers at home, in the office, on the person, etc. would have questions that would be constantly updated on a minute by minute basis. The information could be hard data, not bibliographic citations. The SDI idea is easily adapted to education; the teacher would utilize the framework of the course plus the constant stream of information to create a continuously updated, changing classroom situation highly structured around basic problem solving. This would be supplemented by computer assisted instruction, computer conferencing, video disc lectures and face-to-face contacts.

Problems abound. Prime among them is the information saturation resulting from improperly constructed SDI questions. Specificity will be the order of the day and the ability to browse through information will be greatly reduced by the shear amount of data that can be made available at a moments notice. Another problem is the potential for alienation created by advances in the electronic technology. Issues of individual initiative, and the potential of creating a new lower class of poor--electronic illiterates--who can neither afford nor operate these technologies are among the most pressing problems. Technological Luddites could create major problems as massive societal change comes about.

Conclusion

If all of this is to occur, the place of energy and energy education becomes even more central as public policy issues are defined. The future is full of dangers and many pitfalls, both good and bad, with the continuation of the electronic revolution. One of the biggest problems of all is the lack of being able to keep abreast of our changing world where decisions can no longer be debated in leisure but which have to be made almost instantly as soon as a problem is identified. Thus, to remain on the leading edge of cultural change energy educators must begin to learn how to become more efficient consumers of information so that they can teach students how to work in the world of tomorrow.

Footnotes

1 Daniel Bell, *The Coming of Post-Industrial Society: A Venture in Social Forecasting*(Basic Books, New York, 1976), p. ix-xxii.

2 Maureen Crowley, *Energy Sources of Print and Nonprint Materials* (Neal-Schuman Publishers, New York, 1980), p. viii.

3 E. Edelson, "The Great Gasohol Debate," Popular Science *219* (1), 53-55 (July, 1981).

20.3

INDUSTRY AND UNIVERSITY COOPERATION IN DEVELOPING AND IMPLEMENTING ENERGY EDUCATION CURRICULUMS

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Introduction

Imagine the following scene: A student who has become interested in some aspect of energy education enters a quiet room. His entrance is detected by an ultrasonic device, whose output is constantly monitored by a microcomputer. The student's presence triggers the execution of a stored program that controls a voice synthesizer. "Hello Welcome to the Energy Lab. Come on over and we'll have a talk.", says the computer. As the student approaches the microcomputer displays a menu of available programs:

Choice A. A program that allows the student to monitor the status of the school's solar hot water system at any of eight separate locations.

Choice B. A simulation program that puts the student in charge of a large scale electrical generating plant-either coal fired or nuclear. The participant is forced to make decisions that affect the status of the plant.

Choice C. A computer assisted instruction unit on the mathematics necessary to perform a home energy audit.

Contrast that scenario with the following facts. According to a report published by the National Science Foundation and The Education Department-"Science and Engineering Education for the 1980's and Beyond": Only 17 percent of all high school students take 11th or 12th grade science or mathematics. Schools and colleges have been unable to keep up with the revolution in technology so that their laboratories are hopelessly obsolescent. The report ends by concluding: "The current trend toward virtual scientific and technological illiteracy, unless reversed means that important national decisions involving science and technology will be made increasingly on the basis of Ignorance and misunderstanding." To make matters worse, it has been proposed to eliminate the Science Education budget of the National Science Foundation. As Bill Aldridge, Executive Director of the National Science Teachers Association, points out in his April 3 editorial in "Science" magazine this would mean the elimination of some twenty five programs including:

1. All of the science education research activities, including efforts to learn more about how science and mathematics are learned.

2. All the development of new materials, methods, and curricula in science, including important efforts to link the microcomputer and video disk for science instruction.

3. All programs aimed at bringing minorities, women, and handicapped persons into scientific careers.

4. All of the informal science programs designed for the public and for children.

The elements of a national crisis in science education are clear. If we are to reverse this trend then high quality energy education programs can play an important part. The introduction of the topic of energy presents a unique opportunity to involve students through an activities oriented program in the kind of problem solving and decision making that characterize any scientific investigation. Energy is an ideal subject with which to demonstrate to students that science is fun and that the subject matter of science is relevant to their own everyday experiences. One effective way to support such programs is through the cooperative efforts of private industry and a university.

In Connecticut we have established a three way partnership among Northeast Utilities, Connecticut Yankee Energy Information Center and The University of Hartford's Energy Education Resource Center. Through our mutual efforts we have been able to offer educational programs throughout the state at every level, from elementary through junior high and secondary school all the way to community and civic groups.

The University of Hartford's effort to expand energy awareness is included in the Betterment Through Engineering Science and Technology (BEST) program of the college. Objectives of the program are threefold:

1) To encourage the introduction of energy related curricula into the school systems, and to provide the necessary equipment, supplies and expertise.

2) To promote the concept of "Technical Literacy", a basic understanding of the complex world around us, for all people.

3) To encourage underprivileged students to pursue Engineering, Scientific, and Technical careers.

In an effort to provide energy education programs with staying power the University has established an Energy Education Resource Center which provides an information and materials resource facility for secondary school teachers interested in implementing energy curricula. The center provides a place where teachers can consult with energy education specialists for assistance in either selecting from among existing programs, or in implementing their own original concepts. Experimental equipment is provided to these teachers on a free loan basis so that classroom presentations may be more lively and informative. Available equipment includes fully monitored solar panels, with a complete data aquisition system, bicycle generators for demonstrating electrical power production, scaler/ratemeters with unlicensed radioactive sources, and TRS-80 Microcomputers with which students can study the cost effectiveness of home and school energy savings efforts.

Traveling Assembly Programs:
Each year since 1973 the EERC has sponsored a traveling-assembly-oriented energy education program. From 1973-1978 an Oak Ridge Associated Universities program entitled "This Atomic World" toured schools in Connecticut, Massachusetts, and Rhode Island; in 1979-80 "Energy Today And Tomorrow" took its place. Altogether, during that seven year period we presented those programs to over eight hundred thousand teachers and students. Both programs were warmly received by schools in our area and both have made important contributions to the education of our region's students.

During the academic year 1980-81, however, we offered a new program which was jointly designed by Northeast Utilities and the University of Hartford. The program, entitled "Radiation: Its A Part Of Our World", is designed as a two part presentation. The first part of the program includes a computer controlled multi-image slide presentation which provides an introduction to atomic structure, radioactivity and radiation. The second part of the program is a hands-on activities-oriented presentation which deals with the chemical and physical properties of radiation and industrial and medical uses of radioisotopes. In addition, a teaching packet designed to reinforce and expand upon the information presented by the multi-media show, has recently been completed by Lifetime Learning Systems of Fairfield Connecticut. This packet, which will be provided to all teachers taking part in the program will assist them in developing their own units on radiation, both pre and post visit. Since October, "Radiation: It's A Part Of Our World" has been presented to over 8,000 students and teachers in seventy high schools throughout the state of Connecticut. The program has been universally well received and several schools have already requested return visits for next year. The same program is available to community groups and civic organizations through Northeast Utilities' Nuclear Speakers Bureau.

The majority of our efforts during the current spring semester were focused around the program "Powerplay - The Energy Issues Simulation". This multi-faceted energy education kit, was developed by Lifetime Learning Systems for use at the March 1980 Connecticut Energy Scholars Day. The debut of Powerplay was so successful that it has been packaged as a kit and is being made available to Connecticut secondary schools through the Energy Education Resource Center.

Using articles in a fictional newspaper and vital data sheets, relating to these energy articles, students and teachers actively examine and debate relevant energy issues. The result is a clear view of how decisions reached by special interest groups directly affect the country's total energy and economic outlook. During the spring 1981 semester:

1) Teachers from over 45 schools from throughout the State of Connecticut attended Powerplay workshops held at the Energy Education Resource Center. This workshop introduced them to the simulation and provided training in the use of the kits.

2) Throughout the spring more than 5,000 Connecticut students and teachers took part in Powerplay, either in a single large group assembly setting or in a prolonged multi-period classroom mode.

3) Many special presentations were scheduled, for example:

a) On February 28, over 200 students from all over New England took part in Powerplay as the lead event in A.P.E.C. II (A Positive Energy Conference for Students).

b) On March 14, Powerplay was presented to 150 members of "The Energy Foundation" at Mount Holyoke College.

c) Powerplay will be presented at the 1981 National Energy Education Day State Directors' Training Conference to be held this summer in Tennessee.

Workshops and In-Service Training:
In addition to travelling assembly programs, the Energy Education Resource Center has also supplied in-service training to teachers and to other specific groups who have demonstrated a need for energy education programs.

Two additional programs merit special mention. The Energy Education Resource Center was a sub-contractor to the Greater Hartford Community Renewal Team on a Department of Energy Appropriate Technology Grant. Services provided for the Community Renewal Team were as follows:

1) Design and Construction of demonstration devices (models) pertaining to home energy conservation.

a) Full sized window unit demonstrating proper caulking and weatherstripping techniques.

b) Full sized door unit demonstrating proper caulking and weatherstripping techniques.

c) Full sized wall unit demonstrating range of available types of insulation.

2) Provision of software for use on Model III TRS-80 Microcomputer.

a) A continuous graphical representation of the organization's logotype.

b) A brief program (with computer graphics) illustrating various energy conversation techniques used in heating and cooling a home, with appropriate pay back periods.

c) An interactive question and answer survey on general energy conservation principles.

d) An extended computer aided instruction course in specific energy conservation practices around the home (multiple choice format).

e) A technical program to calculate problem heat loss areas in a structure, given information collected from clients on a building's size, insulation characteristics, etc.

3) Conduct a two week training course for staff members in elementary mathematics, thermodynamics, methods of energy conservation, computer evaluation techniques for auditing home loss and training in conservation techniques.

The final new program that was introduced during the 1980-81 academic year is entitled "Micro-computers for the Elementary Grades". This five session course serves as an introduction to microcomputers and to the BASIC programming language. Simple structured programming techniques are explained and demonstrated with time set aside during each class period for participants to gain "hands-on" experience using Radio Shack TRS-80 micro-computers. Follow up materials, including loans of complete computer systems are available.

This course has been introduced in an effort to meet the needs of practicing classroom teachers who would like to be able to provide their students with computer-literacy at an early state of their education, but who lack formal training in that area. The program has been well received and the Energy Education Resource Center is investigating the possibility of offering a full semester programming course during the spring of 1982 in cooperation with the University's College of Education and Allied Services.

Energy Scholars Day:
One of the highlights of our programs over the last three years has been the development of Connecticut Energy Scholars Day. This annual event, which is jointly sponsored by Northeast Utilities, The Connecticut Yankee Energy Information Center, and the University of Hartford, brings students and teachers from throughout the state of Connecticut together for a full day of energy related programming. Each secondary school is invited to send two of its best students and a faculty chaperone to the conference. Keynote speakers have included: Dr. E. J. Piel, noted author and chairman of the Department of Technology and Society, College of Engineering, State University of New York at Stony Brook, and Dr. Richard Berendzen, President of The American University, Washington D.C. Workshop sessions have included the topics of Solar Energy, Fuel Cell Technology, Fusion Energy, Breeder Reactors, Energy and Food, Energy and Minorities, and Microcomputers in Energy Education.

The 1981 Energy Scholars Day was held on March 24, 1981. The topic of this year's conference was "Energy-The Global Connection." Our keynote address was delivered by Dr. John R. Silber, President of Boston University. The title of his talk was "Danger - Life Ahead." The afternoon session was highlighted by a simulation designed to give participants an opportunity to examine the world's energy situation from the point of view of various foreign countries. In keeping with the theme of the day, lunch featured an international menu with foods based on the cuisine of France, Russia, India, Mexico, and the United States.

The activities summarized above demonstrate the promise that cooperative programs between private industry and universities hold for the future of science education. A cautionary note, however, must be added. As we move further into the 1980's and our programs become microprocessor based video extravaganzas that rival Star Wars with their special effects, and, as the spread of microcomputers, TRS-80's, Pets, Apples, TI's, HP's, Atari's, and Intellivisions, make computer aided instruction a reality in every classroom throughout the country, we must be careful not to lose sight of our original goal--Education. Each of us must make an effort to insure that the energy programs that he or she presents is an educational program designed to increase the students technical literacy and their ability to deal with new information not merely a public relations show designed to promote the wonders of "Free Solar Energy," or the "Dangers of the Nuclear Threat," or the promised utopia of so-called soft energy sources. Those programs which will be successful in the long run will not succeed because of superior showmanship but because of superior educational value.

20.4

'ENERGY-CATED YOUTH' WILL BE PREPARED TO MEET CHALLENGES

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Abstract
Now! Today! Serious attention must be focused on the nation's energy problems. The triangle involving energy, economics and environment must be balanced. As our way of living has become more technical, mechanical and electrical, the energy demands have escalated with little regard to supply, resources, usage and environmental concerns. Just as the situation did not happen all at once, neither will the solution be easy or solved in a short time. This multifaceted challenge wil require the ingenuity, diligence, conservation and perseverance of everyone. Therefore it is imperative that energy education be interwoven into the science courses of the seventh, eighth and ninth grades. Only approximately one-sixth of today's students takes additional science courses in later grades. Thus it is mandatory that energy concepts be included in science courses at the junior high level.

In addition to developing problem-solvers, we must educate a science literate electorate who can intelligently deal with highly technical challenges such as energy, transportation, communication, pollution, space science, and environmental courses. Emphasis must be placed on energy applications as they can be related to scientific principles and theory. Not only will the energy education be very valuable but this approach will revitalize and energize science courses which have lost their 'appeal' to students. The science teachers attending the workshop received teaching materials to use directly in their classrooms. Simple laboratory experiments were developed that can be used with junior high students giving them 'hands on' experience. These experiments illustrated concepts of energy transfer, conversion, generation, and conservation.

The Science Learning Center located in the College of Science at The University of Texas at Arlington houses a resource center for energy materials that will be loaned to science teachers in the Dallas-Fort Worth area. Many audio-visual program and other teaching materials will be available.

This energy education workshop was supported by a grant from The Department of Energy. The director was Professor Ann Benham.

SESSION 21: ENERGY EDUCATION — STATUS

21.1

ANTICIPATED WORKFORCE REQUIREMENTS IN THE ENERGY INDUSTRIES

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Introduction
Over the past several years, much time and attention has been focused on the discovery, production, cost and use of energy in its various forms. Today most of us are aware of the vital part that energy plays in all aspects of our lives--whether we are relaxing at home, performing tasks at work, or enjoying a vacation. In the field of education it is we, working hand-in-hand with leaders in the field of energy, who must be foresighted enough to perceive the need for and provide the training and skills necessary to enable our nations to not only utilize in the most efficient and effective manner those resources which are now available, but also to go beyond current capabilities to discover new resources.

There are two distinct areas to which educators must give greater attention--(1) development of programs for the general public to increase awareness and understanding of energy and energy related issues and (2) development of training programs which will ensure fulfillment of the energy industry's workforce needs during this decade and into the future. We are already at work attempting to increase the understanding of energy issues. In order to accomplish the latter objective, we must first project potential workforce needs. This workforce of which I speak is very broad in range--from secretaries, accountants, managers and maintenance workers to highly specialized engineers and research scientists.

A look at the energy industry's workforce in the 1970's reveals that it was responsible for only 1.6 percent of the total employed workforce. However, energy producing industries accounted for approximately six percent of all engineers, nearly 60 percent of all geologists and geophysicists (excluding those teaching in postsecondary institutions), five percent of engineering and science technicians, four percent of all craftworkers, and 80 percent of all mine operators.[1]

Projections from experts in the energy industry indicate that, although there will be a large number of jobs created during the 1980's, there will also be a large number of jobs lost through technological advances. While the Bureau of Labor Statistics predicts that total employment in the private sector will increase by 28.8 percent by 1990, employment in the energy producing sector is projected to increase by only 13.5 percent.[2] Coal mining is expected to have a 50 percent increase in its workforce; oil and gas well drilling and electric utilities have projected increases of 20-25 percent. Limited workforce growth is predicted in the area of crude petroleum and natural gas extraction, but petroleum refining and other related areas are expected to decline as are gas utilities as output of wells declines.[3]

Coal Industry
Most of the United States' energy for industrial and home use comes from oil, gas and coal. It is anticipated that coal will play an increasingly important role in the production of energy in the United States during the 1980's. According to the U.S. Department of Energy, coal will grow from twenty percent (in 1977) to nearly 40 percent of the total energy supply by the turn of the century.[4] The most labor-intensive of all energy industries--approximately 85 percent of the workforce consists of blue collar workers who mine and process coal--the coal industry will need large numbers of additional coal miners to expand its production. It is expected to have a 50 percent increase in its workforce.

The bulk of American coal is currently mined from deep pit mines in the Appalachia region of this country. The greatest absolute increase in coal-related employment will occur in this region where as many as 68,000 additional coal miners will be required by 1985. Surface mining--mostly in the Rocky Mountain states--has already shown a substantial growth. This growth has caused an immediate need for additional employees. It is estimated that to meet the goal of producing by 1985 one billion tons of coal from deep pit and surface mining, there will be approximately 100,000 new mining jobs. If the current exit rate from the coal industry continues, 40,000 new hirings per year will be necessary.[5]

One hundred thousand employees may be needed for mine construction as new mines are built and rail transportation systems are installed to link remote mines to industrial and residential centers where the energy needs exist. Coal industry labor requirements are expected to increase by 730 percent in the West, 82 percent in the East, and 42 percent in the Appalachia region by 1985.[6] Virtually all of the increase in employment will be in blue collar occupations such as mining, construction and transportation. However, there will be some increase in employment in other fields such as geology and coal exploration, as well as engineering.

Gas and Oil Production
Employment in petroleum and natural gas extraction is expected to increase rapidly as the United States strives to become self-sufficient in these energy sources. Oil and natural gas now furnish more than three-fourths of our energy needs. In 1978, approximately 471,000 workers were employed in activities related to exploration for oil/gas fields, drilling new wells, and processing natural gas.[7]

A wide range of education, experience and skills are needed by workers who explore for oil and gas, drill, operate and maintain wells, or process natural gas. Specific occupations range from specialized geologists involved in exploration to drillers and pumpers engaged in drilling and processing activities. Approximately 60 percent of the 31,000 persons employed as geologists in 1978 worked for petroleum companies.[8] The need for geologists is expected to exceed the number available during the 1980's because of an increase in the rate of drilling. Gas and oil industries have traditionally hired geologists with advanced degrees. However, the industry expects to begin to hire geologists without advanced degrees and provide necessary training until the supply meets the demand. It is expected that the need for earth scientists will grow at a rate of five to six percent per year until 1990.[9]

The demand for petroleum engineers has increased rapidly since 1979, thus the industry has been forced to hire engineers with specialties in other fields. It is predicted that the equilibrium point will be reached by 1983 at which time the supply of graduates will equal the demand.[10] Concern has been voiced by those in the gas and oil industry over whether adequate supplies of skilled workers and technicians to man drilling rigs will continue to be available during the 1980's. Desire on the part of individuals to pursue careers which involve 24-hour callout status and working under harsh weather conditions appears to be diminishing. As a result, the top priority of these companies is to attract and train operators, technicians, mechanics and field supervisors.[11]

Electric Power Industry

Forty percent, or 232,800, of the employees in the electric power industry are involved in generation, transmission and distribution of electricity or customer service. A large number of the workers are also employed in engineering, scientific, administrative, sales, clerical, and maintenance occupations. Although use of electric power is expected to increase through the 1980's, increased use of automatic controls will limit employment growth to about eight percent.[12] Growth will differ from one occupation to another within the industry. It is anticipated that the need for scientific, engineering and technical workers will increase in response to the development and construction of new power generating facilities, research into more efficient energy usage, and efforts to control pollution. Other occupations in this area are expected to experience only slight increases due to larger, more efficient powerplants and increased use of electronic data processing equipment.

Nuclear Energy Field

One of the biggest question marks in the field of energy development is the future of nuclear power in the United States. Once thought to hold many of the answers to our energy shortages, the near-disaster at Three-Mile Island and growing concern over the safety of neclear plants have created a slowdown in the development of additional nuclear power plants. Current projections indicate that, with the exception of those plants that are well along in the construction process, the growth of nuclear power plants will be at a virtual standstill during the next decade. Although approximately 350,000 people were employed in this field in 1978,[13] the uncertainty of future development makes prediction of workforce needs difficult.

If new plants are not constructed, not only will there be little demand for qualified construction workers, but the demand for nuclear engineers, designers and researchers will also grind to a halt. On the other hand, those plants already in existence, and still is use, will continue to need trained personnel for operation and maintenance. In response to increased concern about the health hazards of nuclear radiation, additional persons will be needed with expertise and training in reactor and personnel safety. Employment associated with nuclear research and development will also experience an increase as scientists, engineers and technicians study methods to improve efficiency and safety of nuclear power generation.

Solar Energy Field

Solar Energy is perhaps the most talked about alternative energy source. Some of the country's largest corporations have indicated their belief that this resource will play an increasingly important and expanding role in meeting the nation's energy needs.[14] Overall, employment in the solar industry is expected to grow more than 170 percent by 1983.[15] The greatest portion of this growth is expected to be in the commercial design and installation of solar systems. This sector of the industry employed 8,700 persons--either in part-or full-time positions--in 1978. The solar industry represents one of the best examples of an industry in which retraining programs will be valuable. For example, installation of a solar water heater requires plumbing skills as well as skills in solar unit installation. Thus, plumbers will have to be trained in solar installation.

Research and development activities in solar energy employed approximately 12,500 persons in 1978.[16] It is anticipated that there will continue to be demand for trained technicians and scientists to design and test new solar components and concepts throughout the 1980's. In addition, the continuing popularity of solar conversions will lead to growth in the manufacturing and distribution of solar components.[17] It is indicated that by 1983, more than 36,000 persons will be employed in the solar energy field. This is, of course, based upon continued funding--in part by the Federal government--of research and development activities.

Other Sources

Other potential sources of energy include biomass generation, or the use of byproducts of farm crops. Conversion of grain into alcohol for the production of gasohol is one area that has shown promise. Another source is the use of methane gas produced by municipal waste to generate electricity.

Wind generation of electricity is an alternative that is being researched, as are potential geothermal energy systems.

Because the aforementioned sources are relatively new and, as yet, account for only a fraction of the energy produced in the United States, little data are available on the workforce employed in these areas. Should the feasibility of these resources be established, an increased demand for qualified scientists and engineers to design systems for production will likely follow. This, in turn, will precipitate need for skilled workers to operate the production systems and distribute the output of these alternative sources.

Conservation

It is frequently pointed out that the most effective way of ensuring an adequate supply of energy in the future is to start conserving it today. While some progress in this area has been made, there is still a great deal left to do. The passage of the National Energy Conservation Policy Act of 1978 requires most regulated and unregulated industries and home heating suppliers to provide residential energy audits. While the exact nature of the audits is yet to be determined, it is estimated that there will be a need for as many as 8,600 qualified energy auditors each year through 1985.[18]

In addition to auditors, this act should generate employment for weatherization, furnace modification and other conservation activities. As with the solar installation employment, it is likely that many of today's home contractors and construction workers can be retrained to provide the services required for retrofitting residential property. However, no hard data or predictions are available on the workforce. Additional employment may be generated in the design and production of energy efficient means of transportation and business/commercial buildings. Research and development of demonstration projects funded by the Federal government may provide positions for scientists, engineers and skilled workers.

Summary

In 1978, over 1.6 million workers were employed in the energy workforce in those areas previously discussed--coal mining, gas and oil production, electric power, nuclear energy, solar energy, and other sources. Of these areas, coal mining is expected to experience the greatest employment growth rate during the 1980's--with an increase of approximately 80 percent--as the availability of oil and gas diminishes. Most of these additional positions will be for blue collar occupations such as mining, mine construction and product transportation. Minor increases will also occur in geology and engineering.

In the gas and oil production industries, moderate increases are anticipated for geologists, earth scientists and petroleum engineers. A top priority of these industries will be the attraction and retention of operators, technicians, mechanics and field supervisors as the unattractive aspects of 24-hour callout status and harsh weather conditions take their toll.

A small increase in the electric power industry workforce is predicted through the 1980's. Included will be additional positions for scientific, engineering and technical workers.

The nuclear energy field is, at present, an unknown in workforce predictions. With the adverse publicity of recent events, a slow- to no-growth posture has been assumed in most of the country. However, should events occur to reverse this trend, many additional positions may become available.

Solar energy appears to be a promising and, as yet, fairly unexplored source with great potential in the 1980's and beyond. It is anticipated that research and development will continue to identify other energy sources--biomass generation and wind generation--as the need to develop energy independence gains in importance. The importance of conservation has grown over the last few years thus there will continue to be a small number of additional positions in this area.

Although the future workforce growth in most energy producing industries is expected to be small to moderate, these industries will continue to provide relatively stable positions in the future as research, development and production methods continue and expand.

Footnotes

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21.2

THE STATE OF ENERGY EDUCATION IN AMERICAN HIGHER EDUCATION

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Introduction

American colleges and universities have historically been reactive to changing needs in society, rather than being in the forefront of stimulating or implementing those changes. For example, the American liberal arts college added a needed humanistic component to the previous, more professionally oriented European university model; the land-grant university responded to the country's need for the development of agriculture in the nineteenth century; the teachers' college met the demand for a growing number of trained teachers in a rapidly expanding population; the scientific university, such as M.I.T., responded to the country's special requirements in a period of accelerated development in science and technology; and the junior or community college filled the need for career-oriented postsecondary education not being met by the traditional institutions.

Among today's social forces profoundly affecting higher education, energy is perhaps number one. Colleges and universities are affected by energy considerations in two principal ways. First, they are themselves major primary consumers of energy, the costs of which have become a disproportionate part of the higher education budget. In order to reduce costs they have had to undertake major efforts at direct energy conservation, by means of campus mobilization, changes in buildings and equipment, improvements in operations and maintenance, use of alternate sources of energy, and so forth.

However, colleges and universities are not merely consumers of energy. As the chief educators of the general adult population of the country, their impact on such crucial areas of national concern, such as energy, is potentially enormous. By undertaking community outreach programs, conducting research, writing and disseminating publications, holding conferences, and stressing energy in their course offerings, colleges and universities are able to raise the people's consciousness and knowledge of energy issues. More directly, by providing education, both formal and informal, using both traditional and nontraditional approaches, they are able to teach people how to live more energy-efficient lives in their own homes, businesses, professions, and institutions, as well as how to prepare for careers in both the growing energy field itself and related areas.

The thesis that colleges and universities react to changing social needs rather than anticipate them was confirmed by the recent survey conducted by the Academy for Educational Development of energy education programs at hundreds of colleges and universities in the United States, the results of which were published in *The Energy Education Catalog: Programs in American Colleges and Universities*, Gary S. Schiff, ed., (New York and Washington: Academy for Educational Development and American Council on Education, 1981). Higher education institutions were not, by and large, providing much in the way of energy education before the society itself came to feel that the energy issue was a burning one.

One could date that recognition at about the mid-1970's, when the Arab oil boycott of 1973-74, with its quintupling of oil prices and the inflation that it engendered, brought home to the American people the urgency of the situation. While there have always been energy-related courses and programs in certain technical disciplines, such as engineering and physics, few energy education programs, especially those relevant to energy conservation, management, management, or policy, and to the general, non-technically oriented public, were established prior to the late 1970's.

The growth of these energy education programs was stimulated not only by direct public interest, concern, and demand, but by government support and encouragement as well. Thus, the U.S. Department of Energy--itself only established or concocted out of existing federal energy programs in 1978--appears as the most frequently mentioned outside funding source listed by institutions that have developed some form of energy education. Other federal agencies, such as the Department of Education, various of its sub-units such as the Fund for the Improvement for Postsecondary Education, as well as the National Science Foundation, the National Endowment for the Humanities, the U.S. Bureau of Mines of the Department of the Interior, the Agency for International Development, the Nuclear Regulatory Commission, the Environmental Protection Agency, NASA, the Department of Commerce, and the Department of Transportation have supported diverse energy education efforts.

In addition, both state and local government bodies, using their own as well as shared federal funds, have also helped fund energy education programs. Likewise, a number of major corporations and foundations have joined this effort, thereby further stimulating the development of energy education.

Findings

The range of energy education programs that have mushroomed in the last five years is vast. While it would be impossible within the limitations of this paper to detail them all, they do seem to fall into several major categories, based on the approximately 250 institutions responding to our survey and listed in the catalog.

Perhaps the simplest type of programs are the *informal, noncredit, consumer-oriented courses*, which have the relatively modest aim of teaching specific and direct conservation skills.

Typically, such programs consist of a single, or several, courses, seminars, or workshops, often taught as part of the institution's extension division, adult education offerings, or under a similar rubric. Generally, such programs are found in community or junior colleges, though, increasingly, university extension divisions are offering such programs. The course is usually geared to the lay-person and seeks to teach him/her how to better insulate, or otherwise conserve energy in the home[1] or on the farm.[2] Some courses are aimed at more knowledgeable, semi-professional and professional people, such as plant and building managers, builders, contractors, small businessmen, farmers, and others who may wish to improve their knowledge of applied energy conservation skills.[3] Thousands of individuals are currently enrolled in hundreds of such conservation oriented courses in scores of colleges and universities.

The community colleges have also been in the forefront of developing vocational or career oriented programs to fill actual or potential jobs in the energy field. Most typically, such programs are *full-time two-year programs leading to the A.A. or A.S. degree, and/or a certificate*, attesting to the graduate's technical competence in a specific energy-related vocation or, more broadly, in a range of energy conservation technologies or energy management skills.[4] The specific content of these programs varies widely. In some cases the community colleges have clearly responded to local or regional economic needs. This is true of several programs in coal-producing areas,[5] as well of several institutions servicing petroleum producing areas that have devised associate's degree programs in petroleum technology to meet growing industry demand.[6] In most cases such programs offer a variety of conservation-related technological skills, whether in electrical or mechanical engineering, refrigeration and air conditioning, or in a variety of *newer energy technologies* (geothermal, nuclear, wind, etc.).[7]

By far the fastest growing of these new technologies being taught on campuses across the country is *solar technology*. Responding to what appears to be a skyrocking demand for solar technicians of all types, hundreds of solar energy courses and programs have mushroomed. This is true all over the country, but most particularly in the Sunbelt states, where solar energy holds the greatest promise.[8]

Beyond the teaching of specific technologies and skills to technicians, other *associate's programs* are directed to the *lower-middle management level*. These programs are geared to teaching how to conduct or supervise energy audits[9] and/or how to develop and implement basic programs of energy management.[10]

Energy management programs are offered at higher levels, including bachelor's degrees and master's degrees.[11] Often these are run in conjunction with *business administration* programs. Indeed, next to solar energy education, energy management programs appear to be the largest.and fastest growing sector in energy higher education. Apparently business, government, and the nonprofit sector have all come to the realization that the management of energy resources has become a crucial item in their budget and in their operations. From the student's point of view, word is obviously out that energy management, whether as a degree in itself or as a major or concentration in the context of another degree is a valuable asset in an otherwise tight employment market.

As opposed to the associate's level programs, which are largely technology-oriented and of an applied nature, the higher level energy management programs are most often interdisciplinary and policy-oriented in nature. They generally include courses in the natural sciences (physics, chemistry, geology, biology, and so forth); the social sciences (economics, political science, and international relations, especially of the Middle East, sociology, geography, even philosophy in some instances, where courses on the "Ethics of Energy Policy" are taught); business (finance, accounting, administrative sciences, management, international business); engineering (nuclear, electrical, solar, mechanical, aeronautic, agricultural, etc.); and architecture, where there appears to be an emphasis on energy conservation and efficiency, particularly on the utilization of solar energy.

In some programs there is a clear focus on "*public affairs*" rather than on business per se. In such instances an M.P.A. (Master of Public Affairs), rather than an M.B.A. is usually offered. In still others, *environmental studies*, rather than energy per se, are the central focus.[12]

The aim of these programs is to give the students a broad knowledge and basic understanding of energy questions, including conventional and alternative energy sources; the international and domestic political, social, and environmental implications of energy decisions; and the economics of energy and its implications for business and/or the public sector, where they will find employment. There is even a program which specializes in teaching such energy management skills to selected students from the developing countries.[13]

Closely related to the above are other specialized joint degree programs, notably in *law*, at both the J.D. and, most recently, the LL.M. levels. These programs add to the interdisciplinary mix enumerated above a specialized focus on such things as energy law, environmental law, government regulation of industry, and so forth.[14]

In the area of *education*, while there are no full-blown degree programs specifically designed to instruct teachers how to teach students about energy, a number of institutions do offer courses or workshops on the subject at both the bachelor's and the master's level.[15] Most typically, such programs are conducted during the summer. These courses are often part of pre- or in-service teacher-training or retraining programs in departments of education. They often include instruction in the use of materials developed by the Department of Energy, the National Science Teachers Association, and others. In addition, a number of universities are involved in the development of new curricula and teaching aids of various types (textbooks, audio-visuals such as slides, films, and tapes, etc.) to be used in the teaching of energy to both younger and older students, in some instances on a state-wide basis.[16]

The various departments and schools of *engineering* have been teaching about energy by definition throughout their histories. Yet, they, too, have sensed new needs in society that they were not meeting. Many, therefore, have begun to add specific courses, programs, degrees, and research that are more oriented towards the policy and management aspects of energy.[17] Many are also now stressing an interdisciplinary approach to the study of energy, both within the various engineering disciplines themselves, as well as in other natural and social sciences, particularly economics, again reflecting the central role of energy in our economy. Thus, there are now engineering programs, at both the undergraduate and graduate (master's and doctoral) levels, which offer degrees under such rubrics as "energy systems engineering," "energy engineering," and "energy studies."[18] Some of the updated energy engineering programs are specifically targeted at particular segments of the energy industry, as, for example, electric power, gas or solar.[19]

In an effort to increase public energy awareness and literacy, many institutions have developed *individual courses*, rather than full-fledged degree or non-degree programs, in the field of energy education via both traditional and non-traditional media, such as newspapers.[20]

Two other areas warrant mention to any survey of energy education by colleges and universities. One is *research*, the other community service type project. It would be impossible to cover all the types of energy research being conducted on American campuses today. The immediate impact of such research is often limited, as such activities are usually confined initially to faculty members and a few select graduate students. Furthermore, advances which develop out of university research are often long term. Nevertheless, one cannot gainsay the ultimate role of university level research in all areas affecting energy--scientific, engineering, policy, education, and so forth--including in educating the public.[21] While the role of research is important over the long term, colleges and universities have been active in the last few years in devising *programs and services to the community* which have a more immediate impact upon educating the public about energy in general, and conservation in particular. Very often these services take the form of providing specific or ongoing *information* to the public about various aspects of the energy situation, in such forms as energy information services, publications, libraries, resource centers, etc.[22] Other institutions have used the telephone to provide up-to-date energy information to callers.[23] Still other institutions provide what amounts to free *energy consultation service* to business, industry, and individuals.[24]

Conclusions

As we have seen, the colleges and universities have, in accord with our theory of social responsiveness, made major strides in developing energy education programs to meet society's needs. Undoubtedly, many new programs will be developed in response to felt needs and expressed demands. However, the energy education picture is not all rosy. It must be conceded that the nation's institutions of higher education created such programs only in response to a crisis situation, and even late in the day by that reckoning. With some notable exceptions, most of the programs described above were created within the last two-three years, even though the severity and long-term nature of the energy situation was blatantly apparent even to the layman for a least twice that long.

This sober realization must at least raise some questions about the planning processes and capabilities of our nation's colleges and universities, much as their delayed response to the impact of declining enrollments of the 70's and 80's does. Cannot the nation's colleges and universities, which house some of the best minds in the country, project five or ten years ahead and anticipate major social and economic changes--such as the energy situation and the demographic picture--and their impact, if not for society as a whole, then at least for themselves as institutions? Furthermore, while there is a lot of energy education activity about these days, there are still many colleges and universities, some very important and large ones among them, which have not as yet undertaken any serious efforts along these lines. Much work remains to be done.

Further still, it is as yet too early to evaluate the quality, appropriateness, and effectiveness of the current crop of energy education programs. But, by what criteria, according to which priorities, and by whom are thse judgments to be made? Many of these energy education programs mushroomed in an ad hoc sort of way, much as Black and other ethnic studies did a decade earlier. Precious little time and forethought was expended in their planning and coordination on campus, let alone coordination among different institutions, whether geographic or functional. How many will survive past the next crisis/response cycle remains to be seen.

Perhaps the time has come for educators at all levels, government officials, industry representatives, the nonprofit sector, and other interested parties to get together and evaluate what has been done in energy education to date and to recommend what must be done in the years to come. The theory of the responsiveness of higher education institutions to society's needs has never face a greater challenge than that of energy.

Footnotes

1 Home Energy Audit Program, University of Vermont; Family Energy Project, University of Missouri at Columbia; Project AHEAD (Alternate Home Energy Application and Demonstration), Illinois Central College; "Energy Conservation for the Homeowner" course, Suffolk County (New York) Community College.

2 Des Moines Area Community College and Colby Community College, Kansas (courses on alcohol fuels).

3 Builder/Contractor Program and Small Business Program, Oregon State University; Marquette University, Milwaukee (seminar on energy conservation for building owners and managers).

4 Residential Energy Analyst Program and Energy Management Technician Program, Lane Community College, Oregon.

5 Lees Junior College, Kentucky; Trinidad Community College, Colorado; Roane State Community College, Tennessee; Bluefield State College, West Virginia; Coal Extraction and Utilization Research Center, Southern Illinois University.

6 Muskingum Area Technical College, Ohio.

7 Bristol Community College, Massachusetts; Lakewood Community College, Minnesota; Chattanooga State Technical Community College, Tennessee.

8 Solar Energy Technology Program, Mohave Community College, Arizona; Cabrillo College, California.

9 Energy Conservation Auditors Program, Schoolcraft College, Michigan.

10 Energy Management Technician Program, Tacoma Community College, Washington; Parkersburg Community College, West Virginia; Western Wisconsin Technical Institute.

11 Energy Management Program, Eastern Illinois University (bachelor's level); Energy Resource Management Program, College of Business Administration, University of Denver (M.B.A. level); New York University (M.A. in economics or M.S. in energetics); University of Pennsylvania (M.A. or Ph.D. in energy management).

12 Energy Policy Focus, School of Public and Environmental Affairs, Indiana University (Master of Public Affairs/Environmental Policy Concentration).

13 State University of New York at Stony Brook.

14 Energy Law Center, University of Utah.

15 Western Illinois University; University of Oregon; University of Houston at Clear Lake City.

16 Office of Energy Education, University of Rhode Island; State-wide Energy Consortium of California State University and Colleges; St. Joseph's College, Connecticut; Schools of Engineering and Education, University of Southern California.

17 Energy Management and Engineering Program, University of Evansville, Indiana.

18 University of Arizona (undergraduate degree in "energy engineering," graduate degree in "energy systems engineering"); Georgia Institute of Technology (certificates in "energy engineering" or "energy studies"); Polytechnic Institute of New York (certificate in "energy engineering and policy").

19 Engineering Electronics Program, Applachian State University, North Carolina; Texas A&I University (natural gas engineering); Trinity University, Texas (solar energy engineering).

20 "Energy and the Way We Live," University of California at San Diego (course by newspaper).

21 *Energy Future* (book), Harvard Business School.

22 Energy Information Service, University of Houston, Downtown Campus.

23 Clark University, Massachusetts; New York Institute of Technology.

24 Energy Institute, Ferris State College, Michigan; Northern Kentucky University' Thermography Project, Indiana State University.

21.3

ENERGY EDUCATION IN NEW ZEALAND

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Introduction

Thank you very much for giving me the opportunity to speak to you today and to outline what we in New Zealand are doing in the important field of Energy Education. As the Conservation Officer in the Ministry of Energy in New Zealand, I am part of a 10-man team in the Conservation and Pricing Directorate of the Ministry's Planning Division. The Directorate is responsible for the formulation of New Zealand's Conservation and Pricing Policies.

To put things into perspective, New Zealand is about the same size as Colorado and a little smaller than Arizona and Nevada. New Zealand is populated by just over 3 million people and 60 million sheep. Our economy is primarily agriculture based although government policies since the 1950's have resulted in a large increase in our manufacturing capability. Nevertheless in 1980 approximately 65% of our exports were still in the form of agricultural products.

New Zealand is basically an energy abundant country with one notable exception, oil. Approximately 90% of our oil is imported. In 1972 our oil bill was approximately $94 million. In 1981 our oil bill had climbed to over $1,500million. To illustrate the problem, oil represented 5.1% of our imports in 1972 while in 1980 the figure had increased to 16.9%. Obviously increases of this magnitude have a serious effect on our internal cost structure, on our ability to export at competitive prices, and on our standard of living as a whole.

The main thrust of the Government's energy policy since 1972 has been to use our relatively abundant natural gas and coal to substitute for oil wherever possible, with some success. In 1974 imported oil accounted for 43.6% of our total energy consumption, in 1979 imported oil only accounted for 35.4% of our total energy usage.

The Government has also implemented a raft of energy conservation policies to encourage consumers to use energy more efficiently. An integral and essential part of the Government's energy conservation effort is the conservation campaign. This publicity campaign is designed to make consumers aware of what they can achieve through energy conservation and to help motivate them to take energy conservation initiatives.

Since its inception an important energy conservation campaign objective has been to stimulate constructive thinking about energy problems among young New Zealanders. As well as producing literature and display materials the campaign has provided annual prizes in school science fairs, sponsored competitions, and cosponsored a book on energy futures and an energy simulation game developed by the Commission of the Future. Whilst they continue to be important these efforts are rather piecemeal and it was appreciated in 1978 that a more thorough approach was needed. To this end the Ministry approached the Department of Education and a dialogue was established on ways and means of providing schools with further assistance in their awareness and understanding of New Zealand's energy needs and energy conservation. The Department of Education was appreciative of the importance of energy within the school curriculum, but indicated that due to pressures on responses it would be unable to provide finance and personnel. The Ministry of Energy responded by offering to fund a teacher for a year. This offer was accepted and a secondary school teacher was seconded to the Department's Head Office.

The Department of Education was mindful of past experiences of some curriculum development exercises which have gone ahead without a clear idea of the status quo and without any well-defined objectives in mind. Thus, before he began developing energy-related teaching resources the seconded teacher was given an initial brief to prepare an investigative report.

To avoid the mistake of developing resources which fail to take cognizance of specific needs as perceived by teachers themselves or which merely duplicate material already in existence, the following areas were investigated:

What provisions there are in the curriculum for the study of energy?

What is actually being taught?

What resources are available?

What is being used?

What are teachers' needs?

What is being done overseas?

What new or supplementary resources should be developed for particular subject areas and levels?

What long-term strategies should be adopted to ensure the implementation and continuation of energy education in schools?

In addition, the energy consumption in schools was investigated on the premise that if school children are to be asked to look into energy consumption in their own homes, then they will inevitably ask questions about the energy performance of their school. The subsequent research was incorporated in a discussion document entitled "A Report on Energy Education in New Zealand Schools."

The report firmly established that provisions for the study of energy existed in a wide range of subject levels in both the primary (elementary) and secondary (high) school curriculum. A review was made of all existing official departmental syllabuses, guidelines and presciptions. A selective list of these was published in a supplementary document "Energy: An Index of Curriculum Possibilities." This index ran to 90 pages and included only the explicit and more important and obvious implicit provisions for the study of some aspects of energy. A list of important energy concepts formulated by your own US National Science Teachers' Association was published in their "Energy Education Workshop Handbook." These concepts were matched against the content requirements of the existing New Zealand syllabuses and almost without exception there was a stated provision for the study of all the listed concepts. Through this process it was firmly established that energy was multi-disciplinary in nature and not a candidate for a new, separate subject in an already over-crowded curriculum.

The energy report also favoured an infusion approach whereby specially developed energy units would be slotted into the existing curriculum at appropriate levels and junctures. As there is a wide scope for real subject integration in the New Zealand primary school system, an inter-disciplinary approach was advocated at this level. But because of the subject specialization at the secondary school level it was recognized that infused units of work would be oriented to a particular subject, but providing significant overlap with other subject areas.

Two examples of integrated approaches to the study of particular energy concepts are 'heat energy' and 'electrical energy'. Here an aspect of energy takes an inter-disciplinary theme that focuses on science in association with other subjects. The existing opportunities for the study of energy are quoted verbatim from the official syllabuses. The process illustrates that there is little need for additions to be made to the content of the existing syllabuses. Some minor modifications and re-interpretations are all that is required to ensure that an appropriate emphasis is given to the significance of energy across the full range of the curriculum.

However, despite the existence of a theoretical framework for the study of energy in all aspects, the investigation discovered that in practice the teaching of energy was very fragmented. Teachers were keen to teach about energy but they felt that they lacked adequate guidelines and appropriate support materials. Also, the very extent of the possibilities for the study of energy in different subject areas contained the inherent danger that students would be over-exposed to a topic at different levels. Careful integration was required to avoid needless duplication and over-kill as occurred during the 1970's with pollution-related issues.

The main recommendation of the report was that a joint energy education programme should be established. This recommendation was accepted and a formal Energy Education Programme (EEP) was established for an initial period of three years and a projects coordinator appointed. The main thrust of the programme was to bring together teacher working parties who would develop energy-related teaching materials for their particular subject. A secondary objective, but also an important one, was the link-up with the initiatives from other groups including government departments, quasi-government organizations, and private companies. A third stream of development would be the adaptation for local conditions of proven overseas materials. Working through these three concurrent phases the Energy Education Programme was designed to provide the expertise of teachers in the development of teaching materials to ensure that they were in the current educational idiom and of maximum use inside the classroom. I shall deal with each of these phases in a little more detail.

Teachers' Courses and Working Parties

The three-year developmental programme began with a small residential course comprising a group of educators, teachers and officials from the Ministry of Energy. At this course a draft matrix was developed to identify the links across the curriculum. A more recent development on the matrix has attempted to not only show the implications of a particular concept across the range of subject/levels, but also to trace the small energy decisions made daily by individuals and the implications of these on the formal education system right through to the effects on policy information at the Government level. A draft set of aims of energy education were also formulated at the initial course. These aims recognize the importance of knowledge and concepts, but place emphasis on the development of appropriate values and attitudes and the inquiry skills of problem-solving and decision-making. There was a deliberate attempt to make this set of aims direct and straightforward so that when confronted by them the classroom teacher would not feel threatened by their complexity.

The leaders of the 1980 working parties were also inducted at the course. The energy report had outlined the following:

- The relative importance of energy to a particular subject/level, ie, the percentage of a course that energy studies comprise, and whether the topic is compulsory or mandatory.
- The number of available existing resources relevant to the subject/level.

Using the criteria as a basis for selection the following subject/level were chosen for the 1980 working parties: science, forms 1-4 (grades 8-9); geography, forms 5-7 (grades 10-12); home economics, forms 1-5 (grades 6-10); primary science and integrated subjects, forms 1-5 (grades 6-7); primary social studies and integrated subjects, standards 1-4 (grades 2-5). These groups worked throughout 1980 on the production of draft resources which were trialled in schools and evaluated by teachers, and subsequently revised. All these materials are currently being edited prior to publication and national distribution. Some of the resources are teacher-centered, some pupil-centered and others a combination. An underlying assumption in the development of all the materials was that many good resources were already in existence and new and additional ways of using these was a priority consideration. To aid the groups in their awareness of the range of existing resources an extensive 'Energy Education Bibliography' was prepared.

This year six additional working parties have been established and comprise: chemistry, forms 5-7 (grades 10-12); science form 5, (grade 10); economic studies, forms 3-5 (grades 8-10); social studies, forms 3-4 (grades 8-9); language, forms 3-7 (grades 8-12); and mathematics and integrated subjects, standard 2 - form 2 (grades 3-7).

Link-up Phase

Prior to the establishment of the Energy Education Programme the production of energy-related materials had been undertaken by oil companies and other interest groups on an ad hoc basis. Although ostensibly designed with school consumption in mind the majority of this type of publication was designed to fill a multi-functional role, and doubled as general publicity and information material. Much of the material was not directly related to any school syllabus and was mis-directed, inappropriate or irrelevant. It has become evident that before teachers accept new material they need to know quite clearly how a resource fits into their teaching programme, and how to use that resource. The Energy Education Programme has been able to work with outside groups to overcome this problem by providing the expertise of practising teachers during the production process. A good example of this is the multi-media kitset on natural gas developed in conjunction with the Gas Association of New Zealand. This was designed with the objectives of the forms 1-4 social studies syllabus in mind, and promotes the development of inquiry skills through simulations, role plays, activity cards and completion tasks. Unfortunately the dictates of politics and manpower do not allow the Energy Education Programme to respond to all the initiatives from outside groups and many go ahead with their efforts and run the inevitable risk of missing the market.

Adaptation of Other Materials

The energy situation is a global problem and whilst there are appropriate local responses there are many universal perspectives. Energy education made a relatively late start in New Zealand, and we have looked to the more advanced developments overseas for inspiration and guidance. Energy education packages are not exportable per se, but careful evaluation of a number of overseas materials has proved them to be with some modification, suitable for local use. In this way the set of "Science Activities in Energy" folders, published by the US Department of Energy, have been adapted to suit local conditions by the New Zealand Science Advisers in conjunction with practising teachers. We are very grateful to the US Department of Energy for permission to adapt and use the material in this way.

In a similar vein we have negotiated with BP New Zealand Ltd to introduce to all primary schools a teaching pack entitled: "Children and Energy - Pushing and Pulling." This material was originally developed at the Avon Education Authority's Learning and Resource Centre in Bristol.

These two examples of international cooperation in resource production highlight that while our respective countries have a drive for energy self-sufficiency and energy independence, there are many approaches to problems that transcend national boundaries.

We are also developing an energy atlas which will comprise an adaptation of the maps that appear in the publication "Survey of Energy Resources 1980" which was prepared for the 11th World Energy Conference in Munich.

Summary

The three processes outlined - teachers' working parties, link-up with outside organizations and adaptations of overseas materials - are all generating a relatively large number of teaching resources. The corollary to this activity is a programme of adequate teacher-training and instruction in the use of the materials. Our intention is to use the leaders of the working parties as key people in the dissemination of resources at local in-service courses. An energy information centre is being established in New Zealand's largest city, Auckland, and plans are afoot to use this as a focus for in-service training. A long-term proposal is to construct a mobile energy display to tour schools and ignite interest in energy. A teacher-driver would also be responsible for disseminating energy education materials, and directing in-school teacher training.

The effective dissemination of resources is however, faced with an unfavourable economic climate, and its success will depend on the extent that energy continues to be considered as an important and ongoing social, political, economic and therefore educational issue.

There has been in education a perceptible reaction against what is termed the 'crisis oriented curriculum'. Weighed against this, however, the energy crisis has called for a careful review of much of the content of the existing syllabuses, not with a view to removing or replacing that content but to modifying it or amplifying it. Many of the changes that are implied are changes of attitude and new frameworks of interpretation. In New Zealand, as elsewhere, there is a process of education review and a cry from some quarters for a return to the basics. There is also an attempt to establish a core curriculum central to basic education. In this review process energy has emerged as an important thread running through, and to an extent tying together, the curriculum.

The energy situation has been a test of the existing New Zealand school curriculum and the ability of the educational system to cope with pressing social issues. The cooperative Energy Education Programme has gone some way in demonstrating that the "system" is able to adapt to new demands and pressures placed on it.

21.4

RENEWABLE ENERGY EDUCATION - A STATUS REPORT

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Abstract
At the Solar Energy Research Institute a national data base of solar energy educational activities at the post-secondary level is maintained and continually updated. The primary publication from the data base is the *National Solar Energy Education Directory*, now in the third update cycle. The *Directory* is a major tool for use by students and researchers wishing to identify programs, courses, and curricula offered at the nation's post-secondary educational institutions. Beyond this *Directory*, however, a quantitative analysis of the solar energy educational offerings indicates that an interest in solar energy education is dramatically increasing.

This paper will examine this trend in solar energy education from an historical perspective from 1973 forward using the computerized data base. Noteworthy is the fact in 1978, 680 schools offered at least one solar course, by 1979 this had increased to 760; while in 1980 about 900 schools are involved in solar energy education according to the annual survey results.

Detailed analyses will be made of the 900-plus post-secondary educational institutions currently offering nearly 2000 courses and over 250 programs. The distribution of programs and courses will be analyzed by state and by the type of schools (colleges and universities, community/junior colleges, vocational-technical schools) offering solar in those states.

An analysis of solar program offerings will be made. Programs are classified into three types: 1) Solar Curriculum - a curriculum in which the student receives a degree or diploma in a solar field, e.g., "Masters in Solar Engineering" or "Associate Degree in Solar Installation"; 2) Curriculum with Solar Study - a program which incorporates solar offerings into the curriculum so that the student receives solar education while working on a related degree or diploma, e.g., "Ph.D. in Physics" with solar emphasis, "Bachelor's in Architecture" with solar design experience; and 3) Solar Technical Training (Non-Academic Degree) - a program in which the student receives a certificate for study in solar energy or a solar related field, e.g., solar technician. Analyses of program types will be made by the degree offered in each program type. As an example, in 1979 when analyzing the 177 curricula with solar study, one out of eight offered doctorate degrees, one-fourth offered a masters, one-third gave bachelor's degrees, and another one-third made available associate or certificate degrees. In addition, program type will be analyzed by the student training specialization which occurs in the program. For instance, are programs training students in solar engineerings, as heating-ventilating-air conditioning specialists, as architects, etc.? About 15 categories of training specialization will be reviewed.

Solar courses will also be analyzed in detail by academic and non-academic level on which courses are offered. Academic levels are categorized by college graduate, college junior/senior, college freshman/sophomore. Non-academic levels of course offerings include layperson, managerial, professional and skilled labor. Courses will also be analyzed by course topics taught extensively in the 2,000 solar or solar-related courses offered in the U.S Statistics on more than 30 course topics will be presented. Samples of course topics include bioconversion, greenhouse techniques, materials, ocean systems, passive solar, photovoltaics, solar heating and cooling, solar system installation/maintenance, solar laws/legislation, thermochemical conversion, and wind energy conversion systems.

In the final analysis an attempt will be made to ascertain the number of students completing the various course/program types to determine the fit between the number of students completing programs and the current market projections of the need for various skills in the emerging solar technologies.

21.5

ENERGY EDUCATION PROGRAMS IN TWO-YEAR COLLEGES: AN OVERVIEW

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Abstract
Local two-year colleges are playing and will continue to play an important role in translating national energy circumstances for local residents and in assisting their districts to respond with their own appropriate solutions to the problems. The colleges are currently offering a variety of traditional credit opportunities in all forms of energy technology, from the renewable to fossil fuels to nuclear to conservation. These offerings take an assortment of forms in individuals colleges, including courses, sequences of courses, standard degree programs with energy options, one-year certificate programs, and AAS degree programs. My paper will offer a complete breakdown in each of the approaches by energy area on the basis of a recently completed national review conducted by AACJC's Energy Communications Center.

The majority of energy education opportunities in the colleges is offered through their non-credit programs, usually through Adult and Continuing Education departments. These opportunities take the form of courses, workshops, seminars, and forums. Courses most often involve information-sharing through classroom discussion. Workshops and forums generally include hands-on experiences with practical applications for small business, industry, and homeowners. Forums are designed as awareness sessions. Nationally sponsored workshops for teachers have also been conducted recently. Among these are Alcohol Fuels Seminars, Solar Installers Training, and Faculty Development workshops. Examples of each approach will be presented.

Colleges have opened energy information centers for their communities and are operating various applied research activities. The centers take different forms, but their purposes are similar. Action research laboratories include: college as lab (conservation), farm as lab (integrated farm energy system), distillation column as lab (alcohol), national testing lab for wood heating appliances safety,

community renewable energy resources lab (catfish pond, food canning, greenhouse, etc.), and feedstock harvesting and processing (alcohol). Colleges are also leading the way in facilities conservation, with several colleges the recipients of national awards in the past five years.

Colleges have achieved these results in spite of serious handicaps, including: funding restraints at both the local and national level, fluctuating federal policies and guidelines, uncertain commitment at the local area, confused manpower needs and requirements, and a general local reluctance to introduce new programs in the college curricula.

The future holds much the same, unless the problems noted above are resolved or diminished. One new development might be the creation of networks of colleges that would offer specialty parts of a complete technology program; that is, in alcohol training one college might focus on fermentation and distillation, while another college might offer engine conversion and end-product handling and marketing.

SESSION 22: AUDITOR TRAINING AND CERTIFICATE PROGRAMS

22.1

CLASS II AUDITOR CERTIFICATION: PRE-RCS TO RCS TRANSITION

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Abstract
Pre-RCS (Residential Conservation Service) Program conditions brought about the need for an Auditor Certification Program. A twenty hour curriculum designed to meet this need was developed and implemented in the State of Rhode Island in 1978, 1979, and early 1980. Following that period, the course was upgraded to meet new conditions mandated in the RCS Program. The setting, objectives and content, operations and results of this program will be discussed.

Introduction
In 1978 prior to the introduction of a federal RCS program, a curriculum was developed to meet a set of needs related to Auditor Certification in the State of Rhode Island. These needs arose from a decision to standardize State Residential Energy Audit procedures following Project Retrotech methodology. Further, the State Energy Office was receiving and processing a large number of telephone inquiries, through its 'Hot Line' Service, which requested lists of recommended sources for audit and contractor type services. In addition, the Governor's Energy Office felt a need for effective training for persons in the energy industry who have close contact with residential energy problems, i.e., contractors, builders, utility representatives, fuel oil dealers, insulation installers, etc.

A twenty contact hour eight module curriculum was developed to meet these needs. Class II Auditor Certification is granted to those who: pass a two part examination following the curriculum objectives, sign a financial disclosure agreement, and agree to use state audit procedures when promulgating their state certification.

The course ran seven times prior to state implementation of the RCS program. It has since been upgraded to meet our RCS State Plan, but the overall structure has remained the same. Periodic seminars (mini-courses) are used to refresh and update pre-RCS auditors. The objectives of the curriculum, the operation of the course, and some results of a total of thirteen offerings are presented in the sections that follow.

Course Objectives and Operation
The course is divided into eight modules and has normally been run in a two session per week schedule over a period of four weeks. On two occasions the program was squeezed into a two day intensive schedule for a Department of Community Affairs group (pre-RCS) and a group of utility representatives (post-RCS). The curriculum objectives for each module are as follows:

1. Energy Basics: Definitions, Units, Concepts of Efficiency
   - To be able to quote a correct definition of:

     Energy and thermal energy
     Power
     Efficiency (physical and economic)
     BTU
     Energy Efficiency Ratio (EER)
     Heat Capacity, Specific Heat and Density
     Coefficient of Performance (C.O.P.)
     Heat Flow
     Temperature
     Heating Degree Day
     Cooling Degree Day

2. Heat Loss/Gain Mechanisms
   - To be able to recognize and explain conductive versus infiltrative heat loss.
   - To be able to calculate the hourly and seasonal conductive heat loss rate through a surface given the temperature difference, R or U value of the surface and its area.
   - To be able to calculate the hourly and seasonal infiltrative heat loss rate through a crack given the temperature difference and the appropriate Q value (B value) of the crack.
   - To be able to calculate, given appropriate tables, the R value of a composite surface.
   - To be able to identify Q values (B-values) for a crack given appropriate tables.
   - To be able to describe the components of heat gain for a residence.
   - To be able to explain the basic operation of a heat pump.
   - To be able to describe the cooling load given appropriate data.

3. Billing and Field Audits

- To be able to summarize residential utility bills and extract consumption trends and costs of the energy forms used.
- To be able to convert fuel costs in original units (e.g. $/gal) into common units $/BTU or $MBTU given conversion factor tables.
- To be able to quote the average current local prices of gas, electricity, fuel oil, and wood in residential use.
- To be able to quote hindsight design temperatures and degree days for this region.
- To be able to reconcile heat loss from a billing audit with those from a field audit.
- To be able to list and describe the fundamental concepts and purposes of a field audit.
- To be able to quote the differences between a program audit, a Class B Audit and a Class C Audit.

4. Residential Conservation Service (RCS) Audit

- To be able to perform an RCS audit on a model residence,
- To be able to calculate payback information on standard RCS Energy Conservation Opportunities (ECOs).

5. Vapor-Moisture-Air Quality Problems

- To be able to list and describe the factors governing vapor transmission through barriers and the appearance and effects of moisture within residential surfaces.
- To be able to list and describe the basic remedies for vapor-moisture problems.
- To be able to list common household air pollutants and their sources.
- To be able to quote the qualitative relationship between air quality (humidity-air pollutants) and ventilation rates-internal pressures.

6. Evaluation of ECOs and Life Cycle Costing

- To be able to list and define the standard physical and economic indices used in the evaluation of an ECO including: energy saved, cost avoidance, savings investment ratio, simple payback, present value of savings less costs, rate of return on investment.
- To be able to display a cost or savigns stream for an ECO.
- To be able to calculate the present value of future cost or savings given a discount rate, year of occurence and an appropriate table.
- To be able to calculate the present value of a future cost (savings) incurred (accrued) yearly for a given number of years at a given discount rate given an appropriate table.
- To be able to evaluate two ECO alternatives having different cost streams using present value techniques.

7. Space Conditioning Systems: Sizing and Efficiency

- To be able to estimate from energy audit data design sizing for a heating system.
- To be able to list the basic processes and factors affecting heating system efficiency and procedures used to maximize this efficiency including CO2 testing, stack temperature control, flame retention and furnace maintenance items.
- To be able to identify a 'program audit type' of heating system.
- To be able to explain the relationship between combustion efficiency, steady state efficiency and seasonal efficiency for combustion heating systems.
- To be able to determine seasonal efficiencies from steady state efficiencies for different heating system types using available charts or tables.
- To be able to quote the wood burning cycle and to use the principles involved to discuss efficiency applications in wood burning.
- To be able to recognize and explain the functions of various components and practices involving wood burning stoves.
- To be able to recognize and qualitatively explain the operation of a vapor compression refrigeration cycle and the operation of a heat pump in both the cooling cycle and a heating cycle.
- To be able to quote a correct definition of EER and COP.
- To be able to list insulation types and applications in current use.
- To be able to identify the wall framing and offset trussing methods in current building technology.
- To be able to describe proper installation for common insulation applications.
- To be able to quote current thermal efficiency code in summary form for the State of Rhode Island.

These revised curriculum objectives are similar to those in the pre-RCS program. Notable differences exist in the modules dealing with air quality, space conditioning systems, and the program audit procedure. (The program or Class A Audit and the corresponding Class B Audit was developed for the State by one of the authors; these are currently being used in Rhode Island's RCS program).

Resources for the course consisted of a variety of handout materials and a draft copy of a textbook following the above objectives. The textbook as of this writing is set for publication in Summer 1981 by Petrocelli Books, Inc.

Results and Discussions

Registrants are charged a nominal fee for which they are entitled to receive materials and the textbook. The time between registration and the first class is often several weeks. This time gap and the negligible penalties for withdrawal are responsible for the large number of pre-course withdrawals. The recent trend has been to over enroll a course anticipating that for one reason or another there will be many no-shows. The unusually high pre-RCS participation in the course came as a surprise to the authors. When the first course offering was announced, it was anticipated that perhaps ten to fifteen students could be expected. Instead, the office over subscribed the first section and filled two subsequent sections.

The certification process does not require course participation. Following each course offering, the state runs an examination session open to course participants and to others who have demonstrated some experience in the residential energy field. The examination tests accomplishment of the curriculum learning objectives and consists of two parts, a multiple choice section and a model audit analysis section. Prior to the RCS program, the past criteria involved a passing grade for both parts. The State RCS plan now requires the examinee to receive an average score which is above the passing level. Sixty percent of those taking the course have passed the examination and, while at first glance this rate appears to be low, given the openness of the registration process to individuals with a broad spectrum of educational backgrounds and experience, and given the constraint of a twenty contact hour program, the rate is not unreasonable. Further, the passing rate among those not taking the course, a group that perceives itself as generally experienced in the residential energy field, is only twenty-seven percent.

A short solar extension curriculum has been written and implemented and mini-course updates have been offered for auditors certified in the program. Nearly all of the certified auditors from the pre-RCS period have participated in the RCS update.

Not all of the individuals who successfully complete the course and pass the certification examination choose to become certified auditors. A little more than half of those passing the examination have requested certification. There are currently 108 certified Class II energy auditors in Rhode Island and nearly twice that number of individuals who can offer reliable advice on a broad range of residential energy management matters.

Several programs have emerged in the period that Rhode Island's program has operated which involved literally hundreds of contact hours to produce certified qualified auditors for RCS or similar programs. Some of these have concentrated on the participant, attempting to provide employability to the educationally and occupationally disadvantaed. The program described in this paper has placed emphasis on the homeowner. It seeks to place fundamental principles of energy science and energy economics and residential applications of this science in the hands of those who are close to, if not part of, residential energy problems. By setting one's sights on an improvement in the quality of residential energy management decisions, one must sacrifice somewhat the potential for being able to certify large fractions of those participating in programs expected to have a relatively immediate response to an urgent need for credible information and services.

The program described in this paper has been a cost effective one for meeting mandated state program needs and those urgent demands for sound targeted community information.

22.2

CERTIFICATION IN ENERGY EDUCATION: WHAT DO WE WANT IT TO MEAN?

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Abstract

The field of energy education is like an infant whale. It has all the characteristics of immaturity while gaining weight at the rate of 400 pounds a day. A simple structural feature such as windows, for example, has created a glut of sophisticated knowledge about optimum air spaces, the R-value of air films, treated and tinted double and triple glazing, thermal shutter designs, thermal by-passes, and moisture problems. Yet, super-scientific studies and rather exotic testing equipment youthfully leave unanswered the question of mature inquiry: What does it all mean? Having the information is one thing. Relating it to practical daily life is another.

Certification, generally speaking, is an effort to predict that workers in a field will be able to successfully relate field-specific information back to real-life situations. The value and importance of certification in energy education is emerging as a burning issue for students, instructors, and program administrators alike. Having the information is no longer sufficient. We need predictable standards of job performance.

This paper briefly outlines a broad conceptual framework within which to consider the question of certification. Examples of the first few certification efforts in the field are discussed. Some approaches to certification in other fields are then described, with attention drawn to the advantages and disadvantages of each. Finally, recommendations for certification in energy education are provided.

Certification Efforts in Energy Education

The recent burgeoning of Residential Conservation Service (RCS) Programs has greatly increased the numbers of topics every energy person needs to know. One of the most clearly defined careers in the field right now, and one that reflects this information explosion, is that of the residential energy auditor. The role of the residential energy auditor is used here to illustrate the certification issues that need to be addressed.

Some utility companies began home energy conservation programs five years ago, when it became more cost effective for them to provide consumer education than to build new plants. By the time the Department of Energy (DOE) launched its nationwide RCS program a year ago, solar and other forms of renewable energy had become so important to the total energy picture that utilities were mandated to train auditors in both conservation and renewables. Even then, only the last chapter of the *RCS Auditor Training Manual* (DOE, 1980) was devoted to nenewables.

Two months later, when DOE sponsored a series of sessions across the country for those who had to design, implement and evaluate auditor training programs, fully three-quarters of these week-long "Train-the-Trainers" programs were devoted to renewables technology. Part of that weighting of content was due to the need to "sell" renewables technologies to the utility companies, so that they in turn would sell it appropriately to their auditors, so that they in turn would sell it appropriately to utility customers.

This example raises one of the stickiest questions about certification. How do you maintain control of the content being certified when so many variables of process have such potential impact? If, for instance, a participant's bias against the practicality of solar did not change one whit as a result of the DOE Train-the-Trainers sessions, what would the renewables portion of his/her auditor training program look like? It might be cursory at best; the biases passed on at worst. Suppose someone takes auditor training primarily to use the audit as a marketing tool for solar hot water collectors? Very likely the information in Chapters 1-8 would receive cursory treatment in this case. Making renewables Chapter 9 in the manual does not insure uniform instruction or application of the material.

DOE dealt with this issue by working with Educational Testing Service (ETS) to develop a national auditor certification exam. Members of our staff at the Energy Education Center who had co-authored the *RCS Auditor Training Manual* were invited to submit sample text questions to DOE and ETS. Wouldn't you consider it wise to use the authors of a training manual to develop items for the certification exam? We thought it was. After all, the authors had already developed study questions for the manual.

The first set of questions the authors submitted to ETS bombed. There is, it seems, an exact science to writing test items and integrating them into the total impact of the exam. There are ways of confounding the test-wise with questions; there are delicate ways of equally weighting multiple-choice responses. The point is, developing a nationally valid and reliable certification exam required at least as much testing expertise as it did energy expertise. Such a document of necessity must *exclude* far more of the test-taker's knowledge than it includes. It tests a body of knowledge that the imaginary "national auditor" must have within the much larger body of knowledge a real live auditor has.

Where states have chosen to certify their auditors with the ETS exam, they have predictably run into snags. The exam is such a carefully abstracted composite "national auditor" that regional concerns are obliterated. For example, everyone who takes the test must have 70% of their auditing knowledge on heating loads and 30% on cooling loads, because that is how the national picture averages out. In order to get auditors nationally certified, states have to tailor their training to that 70/30%, then provide additional training for the regional concerns their auditors need to address.

By ways of contrast, some states opted to develop their own exam, to certify in-state auditors. Massachusetts did that, and added a field certification component to evaluate the auditor on the job. Both the test and the field experience are tailored to the on-the-job needs of Massachusetts auditors.

I know of another state that brought together outstanding technological minds to write test items for an in-state certification exam. It was a disaster. They couldn't agree with each other's versions of truth and accuracy, much less agree upon the content of the exam.

Auditing is but one of many emergent careers in energy education. It is the first in the field, though, to seriously address the question of certification. Admittedly, many existing fields -- e.g., engineering, landscape architecture, resource economics -- have developed substantial energy-related programs and apply to them the established degree requirements and certification procedures in their areas. For the increasing numbers of adult learners who want programs specific to energy, however, we have yet to create specific certification processes that say what standards of job performance we want our instructional efforts to stand for.

Approaches to Certification

The teaching profession, among others, has a long history of certification. Getting a degree in education from an accredited institution is the part that insures some level of uniformity to content. In order to have an accredited program, the institution must have courses similar in scope and sequence to those of other accredited institutions. A "student-teaching" experience is part of the degree requirements, and one of the key predictors of success in the field. While other requirements vary from state to state, the teaching profession generally issues a temporary teaching certificate for 1-3 years, followed by a permanent certificate if the candidate has successfully held a teaching position to that point.

The professional field experience is a common element of certification in widely different fields. Doctors must be interns before they are doctors. Electricians must put in 600 hours -- close to 3 years -- of apprenticeship in the field before they get their independent license. The advantages of supervised field experiences are clear. Performance can be evaluated directly. Real-life problem-solving is the primary characteristic of the work. Errors that occur in the practice of knowledge-application are manageable within the framework of supervision by experienced personnel.

The health professions, the legal profession, and many others use an exam to screen candidates to the field. There wouldn't be an ETS if standardized written examinations weren't widely accepted by our society as a valid and reliable means of predicting performance. Their acceptance may be waning, however. Long-held assumptions about testing are quite controversial these days. Ralph Nader has been drawing attention to ETS and the testing business. ETS finally admitted that it does make a difference in test scores if people are coached on an exam -- i.e., prepared for it. Power companies have an exam for nuclear power station operators, and run prep sessions to help employees get ready for it. During the Three Mile Island crisis, one of many concerns raised was that preparing nuclear power station operators for the questions on the test was far too narrow a procedure for the range of knowledge and skills the operators need on the job (Burkhart, et.al., 1979; p. 43).

Most standardized tests are designed to define a minimum standard of performance or competence in an area. It is a sieve with very large holes. Some fields have diminished the size of the holes by adding simulation exercises to the exam. Particularly in the military, and in aviation, simulation exercises are used as a bridge between knowledge acquisition and its real-life application. Not only can simulation be used to test a person's competence, it can be used to train and retrain workers on an on-going basis. Retraining is fast becoming an adjunct form of certification in technical fields. Because technological advances happen so rapidly, the knowledge required to pass an initial certification exam in a technical field may be obsolete within 10 years (Toffler, 1981).

To provide workers with state-of-the-art information, businesses and professions are devising continuing education requirements. In engineering, for example, institutions such as the University of Massachusetts and the University of Wisconsin have developed "extension engineering" programs. Current engineering classes at the University are video-taped, then the video-tapes are made available to business and industry for purposes of retraining engineers in their employ. At pre-arranged times, the professor of the video-taped course is available by phone to respond to employee questions.

Other professions, such as nursing, simply require members to acquire a certain number of Continuing Education Units (CUE's) per year in their field. Divisions of continuing education have the advantage of being able to respond on very short notice to an expressed need for a course on any topic. Given the rapidity with which changes in the sciences are taking place, it makes sense for workers to identify their educational needs from year to year.

Recommendations for Certification in Energy Education

Each approach to certification that has been described has potential application to the field of energy. Certification for various careers would have little meaning if we predetermined the form it should take out of sheer affinity for one approach versus another. On the other hand, meaningful certification would result from allowing the form it takes to match the job performance needs of particular careers in the field, and to vary accordingly.

Energy technicians need means of keeping abreast of technological advancement. Supervised field experiences are needed by those whose job performance is enhanced by opportunities to practice applying knowledge and skills in real-life settings. Those who design and install energy systems need to master a formalized scope and sequence of related content to inform their practical skills. When a career demands skill in integrating the technical and the practical, the certification process should reflect the person's ability to integrate the two, not just his/her skills in each area. As we begin to devise certification procedures in energy education, let's be guided by the wisdom of matching certification to the meaning we want it to have. Then, the infant whale, like her real-life counterpart, can mature into a respected and enduring feature of our experience.

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22.3

DEVELOPING A CURRICULUM FOR COMMUNITY ENERGY ADVISORS

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Abstract

Project EFFECT (Energy for the Future; Education; Conservation, Training) responded to the growing need for a trained cadre of energy conservation technicians and an equally important need to educate the public about the present energy situation in the United States as it relates to our finite energy resources. Out of these recognized needs grew the objectives of Project EFFECT which were:

1. To create a comprehensive training program for *adults* without previous technical training, applicable to community energy conservation needs, and usable in other communities in a variety of regions.
2. To define the new occupational role of Community Energy Advisor and to provide the training to fulfill this role.
3. To heighten community awareness of energy conservation.

The paper will describe how Project Effect provided a model for adult vocational education and for delivery of community energy conservation education. It will answer the questions:

Can adults without technical backgrounds or higher education be trained to perform the complex technical precedures required in an energy audit?

Can a curriculum successfully combine moduls designed to develop competencies in technical and non-technical areas such as drafting and life-cycle costing and in community education?

Where does the trainee fit into the job market?

What are the implications for future training of community based energy advisors?

22.4

ESTABLISHING AN ENERGY TRAINING SHOWCASE

THE ENERGY CONSERVATION/SOLAR TRAINING INSTITUTE

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Abstract
In 1977, TVA's new Home Insulation Program, a forerunner of the Residential Conservation Service (RCS), initiated a training program for the required new energy advisors. This program developed a nationally-known home insulation curriculum and eventually trained 200 energy advisors. In October 1979, it was decided that the new solar programs TVA was then developing and the Home Insulation Program should combine their training activity in a single institution. At the same time, the RCS guidelines were coming out and a decision was made to move swiftly in the establishment of a separate training facility. There followed a six-month planning process centering on the establishment of a temporary training facility, the selection of a permanent site, and the development of facilities design. This paper will explain the background of the training institute. It will also show the development of curriculum, budget, and cost justification processes that any utility will have to go through in the establishment of a training facility. The paper will discuss why TVA decided to establish its own separate training institute rather than depend on independent in-house training programs or contracting with outside training organizations. Finally, there will be a list of do's and don'ts for the establishment of a training institution.

SESSION 23: SPECIAL PROGRAMS

23.1

SEMINAR ON SOLAR ENERGY TECHNOLOGY FOR GIFTED AND TALENTED JUNIOR HIGH SCHOOL STUDENTS*

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Abstract

The development of a two-hour seminar on solar energy technology and applications for gifted and talented junior high school students will be described. The seminar was tailored to a wide diversity of student background and preparation in the physical sciences. Techniques will be presented which not only conveyed the concepts of the physical foundations of the five major solar technologies (photovoltaics, solar thermal, wind, biomass, and ocean thermal energy conversion) to the students, but also were at a level where the students could understand, assimilate, and remember. The creation and/or use of various media types such as viewgraphs, slides, and films (when available) will be discussed along with an outline of simple demonstration-experiments to promote student interest and participation.

Introduction

A two hour seminar on various solar energy technology and applications topics was developed for superior junior high school students (8th and 9th graders). The solar seminar was one of eight lectures presented by area scientists and engineers to selected students from the greater Baltimore metropolitan region and surrounding countries during the 1979-80 academic year. These lectures typically cover a full range of biological, physical, earth, and health science topics including: chemistry, physics, mathematics, biology, geology, engineering, astronomy, medicine, etc. The program was sponsored by the Maryland Academy of Sciences Education Department.'1 A limited number of students (typically three per grade) are nominated to the program by their junior high school science teachers. Nomination criterion includes: IQ (greater than 120), science grades (A's or B's), satisfactory school behavior, teacher recommendations, and, above all, an intense pupil interest in science. The seminars were held on Saturday morning at local area high schools during the winter months from January through mid-March. The lecture periods were two hours long with a fifteen minute mid-point break.

Seminar Design

The seminar was designed with two basic purposes in mind. The first was to give the students an appreciation for solar energy i.e. how solar energy systems work, how they are presently used, and how they might be used in the future. The second and more subtle purpose was to interest the students in science and perhaps influence their career choice in this direction. To this end, the seminar contained a brief vignette of the author's background and why he chose science as a career along with potential career opportunities in the field of solar energy. The remainder of this paper will concentrate on the first and major purpose, the design and presentation of a seminar on solar energy technology and applications suitable for gifted and talented junior high school students.

The basic behavioral objectives were kept relatively simple and of the type that could be assessed by a simple question and answer period at the end of the presentation. These objectives included: identification of the five solar technologies, resource, collector and energy conversion concepts for these technologies, and how these solar technologies interface with other conventional forms of energy. Emphasis was placed on the fact that the resource is diffuse and location specific - thus solar energy should only be used where it has an advantage i.e. more economic, more reliable, only available form of energy, non-polluting, etc.

Seminar content

The basic seminar was divided into seven major parts: the nature of the solar resource, concepts of energy conversion, and the five accepted major solar technologies (photovoltaics, solar thermal, wind, biomass, and ocean thermal energy conversion).

A. Solar resource

In the solar resource area the major items necessary for student understanding were the nature, availability, and size of the sun's energy. The students readily appreciated that the sun generates both light (optical spectrum-photovoltaics) and heat (optical and infratred spectrum-solar thermal) - easily observed in the typically well lighted classroom. The concept that devices could operate on this energy was perceived immediately when one mentioned a simple demonstration using a magnifying glass and dry paper. They also easily understood that the energy was present only during the daylight hours unless it was stored. Storage methods were more difficult to impart especially when natural storage occurred such as in vegetation (biomass) and in the ocean waters (ocean thermal energy conversion). Descriptions of using wood as a fuel and the idea that the ocean is the warmest in the fall helped to get these respective concepts across. The link between the sun and the wind also caused some initial concern, but planned discussions of climate, water cycle, etc. appeared to allay their fears.

To assess the size of the solar resource, the seminar begins by describing the sun as a raging thermonuclear furnance where every second five million tons of matter are converted to energy with temperatures as high as fifteen million degrees (Fahrenheit). The Earth's annual share of this energy is approximately 9×10^{17} kilowatt hours. Emphasis is placed at this point on the understanding of basic power and energy concepts including kilowatt and kilowatt hours. The magnitude of the sun's available energy is further emphasized by showing that a typical (large) house in the eastern United States uses approximately 5×10^{5} kilowatt hours per year. In fact, the entire United States consumes only 2.5×10^{13} kilowatt hours per year. This energy is the equivalent of enough crude oil to fill a 6,000 ship super tanker fleet each containing 2.3 million barrels or enough coal to fill 4×10^{7} railroad cars each containing 83 tons. The Earth's annual share of the sun's energy is still 3×10^{4} larger. This extraordinary number implies that a single day's sunshine would satisfy the world's energy needs for approximately fifteen years or in twenty five days the quantity of solar energy striking the Earth's surface would be equivalent to all the known fossil-fuel reserves.

At this point, the two major constraints on using al this abundant energy are introduced, i.e., 1) the resource is diffuse or distributed so that a considerable collector surface area (which is usually costly to build) is required to gather enough energy to be useful and, 2) the sunshine is intermittent due to weather, season and location in addition to the normal day-night cycle.

B. Energy Conversion
Once the concepts of the solar resource are described, then the basics of solar energy conversion are discussed. The five solar technologies are introduced along with their stylized representations. These stylized representations are shown in Figure 1 and used throughout the seminar to remind the students of the basics of each solar application area. Each solar technology conversion method is presented along with its "natural" form of energy output i.e. photovoltaics - electricity; solar thermal - heat; biomass - heat, fuel; wind - mechancial, electricity; and ocean thermal energy conversion - electricity, chemicals. The idea of efficiency loss by not using the energy in its natural or most efficient form is stressed through a simple example of the typical automobile where only about six percent of the energy in the gasoline is actually converted to motion of the automobile - the rest is lost in the inefficiencies of the various energy conversion steps.

At this point distinctions are made between the natural (biomass, wind, ocean thermal gradient) and technological forms of collectors (photovoltaic, active solar thermal). The total biosphere participates in the natural collection process - the earth (and vegetation), the wind, and the water provide free collector surfaces. Thus, the energy costs for natural systems are determined by the converter costs, e.g., the ocean thermal gradient ship, the wind turbine, etc. The technological options require the construction of a man-made collector before any conversion can be considered which typically adds extra cost to the energy conversion system.

C. Five Solar Technologies
Detailed descriptions and applications of the five solar technologies are presented. Simple diagrams which convey the basic physical principles are used instead of formulas and complex illustrations. For example, a simplified diagram of a photovoltaic cell is used to explain the basic parts of a common "solar" cell as well as how a cell operates including charge pair creation, charge separation and collection.

Following a description of the basic collector, the collector energy system is presented. A generic example for photovoltais emphasizes system components as well as showing how individual cells are integrated into modules and modules into arrays. Other components include: power conditioning equipment, power storage equipment and utility interface controls. In most solar-electric systems a proper utility interface may allow the postponement or elimination of the installation of on site storage. This type of discussion leads naturally to energy sell back, rate structures, laws, regulatory factors and the entire role of the domestic utilities in the area of solar energy.

Instructional Media
The instruction media created consisted of three basic parts: a color slide presentation, appropriate hard copy reference material, and a series of basic concept demonstrations.

A. Slide Presentation
Approximately seventy working slides were used in the initial presentation in addition to a title slide, several slides containing the stylized energy representations which were inserted at appropriate points to remind the students of the areas they had covered as well as introduce each new topic, and five summary slides. The working slides were relatively equally divided between seven major concept areas: the solar resource, energy conversion principles, and the five solar technologies. All slides were kept as simple as possible using pictures in place of words to illustrate the point. Slides containing cartoon characters seemed to be appreciated the most. Each solar technology was presented in basically the same format: an introductory slide, followed by a review of the solar resource, its distribution and measurement, the basic principles of the specific solar energy conversion technology, the generic components of the energy system, current uses of the system (if any), and its projected future applications. The five summary slides presented a capsule overview of each of the five solar energy areas and asked two to three basic but comprehensive questions that the students should be able to answer. Student responses to these questions were elicited and an open discussion and review of the topic area usually ensued.

B. Reference material
The reference material provided to the students consisted of a fact sheet for each of the major solar concept areas as well as a selected reading list. The fact sheet on photovoltaics contains: the origins of the word photovoltaic, the basic description of a solar cell and how it works, typical energy outputs of current cells, major cell types, future directions and the authors assessment of this technologies future potential. The reading list was selected for its readability by junior high school students and its potential availability at the local school level.

C. Demonstrations
Several simple demonstrations also promoted pupil interest and informal discussion. The basic demonstrations involved the use of a small high intensity lamp to simulate the sun (these lamps are readily available and are moderately priced) and single or multiple photovoltaic cells. The output of the cells is connected to a small toy motor or to an inexpensive digital voltmeter. Students see the direct conversion of light to electricity and to mechanical motion in the case of the motor. They also can appreciate what happens when the light is turned off (night time) or when an object is passed in front of the "sun" simulating the effect of cloud cover. Tilting of the cell also illustrates the effect of angle of incidence. If the cell circuit is set up properly current can be monitored and with simple opaque area masks it is possible to show that cell current and hence power increases linearly with area. Other demonstrations involve the use of the lamp with thermometers, focusing lenses, etc. Wind mill and ocean thermal energy conversion ship models also heighten student interest and participation.

Summary
A two hour seminar on solar energy technology and application suitable for use with gifted and talented junior high school students was created. From the overview question and answer period which followed each lecture (presented three times during the 1979-80 academic year) the basic behavioral objectives of solar technology identification, resource identification, and application identification were

achieved. The seminar primarily relied on a color slide presentation supported by basic written reference material and simple concept demonstrations. It should be emphasized that media construction, topic flow and student-instructor interchange should be designed to achieve maximal pupil interest and pariticipation.

References

* Solar Seminar was presented several times during the 1980 academic year as part of the Student Science Seminar Program sponsored by the Maryland Academy of Sciences.

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23.2

ENERGY AWARENESS AND EDUCATION IN AN INDEPENDENT BOARDING SCHOOL

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The boarding school environment provides a unique opportunity to combine classroom effort with practical application. At Chatham Hall, we have only a few day students and most of the faculty live in school owned houses on campus.

During the academic year 1979-80, the physics course centered on energy. Using the textbook by Robert Romer, ENERGY: AN INTRODUCTION TO PHYSICS (W.H. Freeman and Co., San Francisco, 1976), we investigated basic physics concepts. The text material was supplemented by many laboratory experiences gleaned from various sources by the writer. In addition, students were required to use the school library and the science library and to read current articles which related to the topics studied. Many of the supplementary references were so helpful that copies were made and assembled in notebooks for classroom use. Students were encouraged to read an clip local newspapers and current magazines. There were posted on bulletin boards and, if valuable enough, copied and put into the notebooks. Many companies and the Department of Energy have audiovisual materials available which we found helpful. A word of warning on free films - order well in advance with at least two possible play dates.

As the physics students learned about the energy problems facing us, they became interested in doing something within the school to change our habits. To ascertain where we were in energy usage, we obtained data from the business office on the amount and cost of the electricity and oil used throughout the school during the previous year. As much as possible, we tried to determine usage by separate buildings. This was difficult and in many cases impossible since few of the buildings (except houses) are heated by separate furnaces and most of the buildings (including houses) clustered on the hill are on the same electric meter - the "main meter." Nonetheless, we did discover that the fuel and electricity costs are a significant part of the school's cost of operation. To even a casual observer, energy was being wasted in obvious ways. So often girls would leave lights and radios or stereos on when they left their rooms. Since our Honor Code requires that one not enter a girl's room unless she is there, such things were not turned off by others. During the winter months, girls were very casual about leaving windows open and unaware or indifferent to the heat loss occurring.

From the State Office of Emergency and Energy Services (VEO), we got building audit packages for every building on campus. We met with the maintenance supervisor and went over the audit requirements carefully. Our goal was for the physics students to audit some buildings and to try to begin to involve more community members in energy conservation efforts. We gave each family an audit package and encouraged them to study the material. We hoped that they would prepare the audit form for their homes and we offered to help. The class completed the energy audit forms for one family house with 6 average size rooms and for the Rectory which has over 10 rooms, many of them quite large. These forms were sent to VEO for analysis and recommendations.
Physics class members made signs about energy conservation and made announcements in assemblies about the energy being used and, especially, about wasteful habits. They encouraged others to help with the audits and to try to monitor themselves and their neighbors.

While conducting the audits, the students noticed some things that they could do immediately and did them. In the house, they placed perimeter insulation in the joint between the basement ceiling and the floor joists in both basement rooms. Also, they insulated around and between the heat vents to and from the crawl space. They asked the maintenance men to weatherstrip the basement door and to clean the furnace. As a result, there was a noticeable reduction in the amount of cold air coming into the basement. Interestingly, these steps were among the few recommended by the VEO analysis of the house. In the Rectory, they closed some under-the-house vents that had probably not been closed in years. They also recommended that attic insulation be improved.

Since part of our energy education effort involved trying to keep somewhat abreast of new developments, we volunteered to help field test THE SOLAR ENERGY EDUCATION PROJECT from the New York State Education Department and funded by the U.S. Department of Energy and others. They physics class members built and tested several solar stills and did library research on solar energy. These were activities 17 and 41, respectively. Also, since the writer teaches chemistry, she had the chemistry students try "Solar Energy and the Heat of Hydration" (activity 35).

For all the students, the field study was a worthwhile undertaking. It showed them that curriculum efforts are on-going and really made them feel that they were contributing to a valuable project. Their evaluations were surprisingly astute and detailed and they appreciated the chance to contribute. Looking back, it seems that, other than the two audits, the major achievement during 1979-80 was to bring the topic of energy conservation to the forefront. Our interest and involvement in energy awareness and education efforts made it clear that there were some persons who cared and were willing to work to involve others in energy conservation.

Last year (1980-81) there was no physics class since we tend to offer physics in alternate years. Fortunately, the Ecology Club decided to take on energy awareness and education as part of its emphasis. This club had been formed the previous year at the urging of the Virginia Division of Litter Control and is chartered by them. The Ecology Club is sponsored by the Chatham Rotary Club and the writer is its faculty advisor. Formed originally to concentrate on litter control, many of the Ecology Club members had been physics students when juniors so had been involved with the previous year's work. All energy efforts last year were extracurricular and under the aegis of the Ecology Club. Again, individual families were encouraged to audit their homes. Although there was interest, this did not happen. It seems that for this to succeed, some of us must actually schedule times with families and help them to complete the forms (this is one goal for next year).

Armed with the information that heating water requires a great deal of electricity and that insulating water heaters and pipes can significantly reduce electrical usage, we decided to insulate some heaters and lines. Our first choice was a water heater in an unheated closet between duplex apartments. To insulate the heater and wrap the pipes took three of us almost two hours. Practice paid off, however, for the last heater and pipes we did -in an attic - took only 25 minutes to do. There are many more heaters and pipes to insulate next year. Families will be encouraged to do, or at least help do, their own heaters and pipes. We had wanted to monitor to ascertain any change in energy consumption due to the heater and pipe insulation. Unfortunately, the buildings were not metered separately, so this was not possible.

In January, 1981, the writer attended a workshop for Auditor certification conducted by VEO and held at Hollins College. Discussion with VEO personnel indicated that it would be wise to audit one of the major school buildings. After consulting with the maintenance supervisor, business manager, and headmaster, it was determined that the library would be a good building to audit.

Because there are classrooms in the library and the main section is used for evening study hall, the area is lighted from early morning (7-8 a.m.) until late evening (9:30-10 p.m.). It is heated by oil burned in a furnace in the basement and therefore oil usage data is readily available. Electricity use is not so easily determined, however, for it is metered on the "main meter" with most of the other buildings that constitute the nucleus of the school. Thus, the only way that VEO could estimate the fraction of the "main meter" electricity used in the library was to know the space occupied by the other buildings on that meter. Measuring the other buildings occupied five girls and two teachers for several hours.

As had happened during the previous year, the fact that some students and teachers were trying to do something to conserve energy caused others to take action. The maintenance supervisor made arrangements with the night watchman to turn the library thermostat to the nighttime setting. A local oil company donated a "Flame Retention Burner" which is supposed to save approximately 30% (we're monitoring). The maintenance supervisor had men put plastic in window screen frames and covered the west-facing windows of the library. It was obvious that the library was warmer after the window covers were installed. Thus encouraged, the maintenance personnel subsequently covered most faculty home windows with plastic for the winter months. In addition, we have asked the local utility company to make a lighting audit of the library to ascertain the feasibility of converting to fluorescent lights.

Throughout the year, Ecology CLub members made "spot" announcements in assemblies about turning off lights, radios,etc., and closing windows. They also put up notices and tried to monitor energy usage as much as possible. It is hard to evaluate the effectiveness of such effort, but, subjectively, it seemed that there was less waste. Also, there was more interest in conservation as evidenced by the fact that several teachers and administrators not directly involved in the Ecology Club efforts made spontaneous announcements in assemblies about energy saving habits, and occasionally sought our advice about certain procedures.

The library audit results have just been received. If it were possible to reduce the hours per day that the library must be heated and lighted, a considerable amount of energy could be saved. Whether this is feasible or not, remains to be determined. If not, perhaps there are areas which have been kept open which need not be and there could be shut down earlier each day to compensate for the long time per day that the library is open. Clearly, this will be a goal for next year. Also, the possibility of changing from incandescent to fluorescent lights and using energy saving ballasts in existing fluorescent lights needs further study.

Last spring we applied for recognition of our project by the National School Boards Association. This group conducted the National Energy Education Day (NEED) program and planned to host the Youth Awards Program for Energy Achievement in June.

In the up-coming academic year, the physics class will again have energy as the central theme. Most of the basic theoretical physics concepts can be taught with this emphasis. In addition, students gain practical knowledge about such things as degree days, payback periods, R-factors, solar collectors, etc. It had been our hope to offer a semester course on Technological Futures. It appears that there will not be enough student interest to do this. Therefore, some issues and concepts planned for that course will be incorporated into the physics course.

So, what has come of the energy awareness and education efforts in our independent school?

1) The entire school community is more aware of how much energy we use, where it goes, and what it costs.

2) It is hoped that each individual feels more responsible for monitoring his/her energy use. Next fall's orientation of new and old students and faculty will include reminders and facts about energy.

3) Faculty members have asked for help with audits next fall and we will try to get started early on those.

4) As the Virginia winner, the Ecology Club president and this writer went to Washington, D.C, June 15-16 for the Youth Awards Program. This was funded through a grant from the U.S. DOE.

5) Although several of the Ecology Club members graduated this year, there is a nucleus which can continue the auditing, insulating, and community awareness and education efforts.

6) With the physics class also contributing next year, it is hoped that we can make more of an impact on the community. As each person becomes more aware of his/her role in energy conservation, we can remind and assist one another.

7) Because we live and work so closely together, our classroom activities can easily carry over into extra-curricular areas and vice versa. Therefore, our energy awareness and education efforts should begin to have significant impact on the entire school

23.3

"TRIPLE E: ENERGY, EDUCATION, AND EMPLOYMENT"

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Introduction

"Triple E: Energy, Education, and Employment," is a community based education, energy, and employment demonstration project focusing on the employment and education of hardcore unemployed youth through the coordination of local energy programs and services. There were three major goals of the $100,000.00 Michigan State Department of Labor Demonstration grant program design:

1. To provide youth with the handicaps of past run-ins with the court system (adjudicated youth), and lack of basic educational skills and/or a high school diploma (high school drop-outs), with a comprehensive program of education, supportive services, employment, and an opportunity to contribute to their community.

2. To enhance and forge linkages among local programs and agencies with the potential to give non-fragmented assistance to the target population, so that the myriad of problems that contribute to a youth being adjudicated and/or unskilled can be addressed comprehensively.

3. To give the target population classroom training, work experience, on-the-job training and transition into unsubsidized employment in energy conservation related occupations such as those associated with home weatherization and restoration; fields for which there is a growing identified demand for skilled and experienced workers.

The project was designed to test the ability of the State of Michigan to enhance and facilitate efficient utilization of *existing* resources among prime agencies, schools, community action programs, local social (welfare) agencies, labor, private employers, and other local agencies which operate youth employment programs. The Michigan State Department of Labor was willing to make the funds available to supplement the components of *existing* programs and services that offer (or would have liked to have offered) allowances and wages to participating youth. The program (demonstration project) operated for one fiscal year with these supplimental incentive funds, and since then has been turn-keyed into various community agencies.

"Triple E: Energy, Education,and Employment

In 1980, the Michigan Department of Labor funded a community project designed to demonstrate efficient and coordinated utilization of resources between Comprehensive Employment and Training Agencies, Schools, local Social Service Departments, Community Action Programs and other local agencies. The local project was required to "target" resources toward high school drop-outs and/or adjudicated youth. Services required included a combination of classroom training, work experience, and on-the-job training culminating in placement into unsubsidized employment. Occupational training and employment positions were to be directed towards fields of weatherization and home rehabilitation.

In Sault Ste. Marie, Michigan, a Canadian border city with 9500 to 10,000 degree days annually with a constant unemployment rate of 20 to 30 percent, the project was designed with six main objectives:

1. To increase educational attainment levels of adjudicated youth and high school dropouts in order to prepare them for qualification for the G.E.D. or credits towards the high school diploma and, training and eventual employment positions in the home weatherization and housing rehabilitation industries.

2. To place the participants in long-term private sector jobs or structured skill training programs leading to private sector employment.

3. To increase post program wage rates of participants relative to pre-program wage rates.

4. To develop a comprehensive and coordinated service delivery system between community programs and agencies serving the target youth population.

5. To assist in community housing rehabilitation, home weatherization, and neighborhood improvement efforts through the training and employment of the target youth population.

6. To develop an energy conservation ethic and to increase knowledge and skills in energy conservation.

Thus, the "target" population (N-16) represented 40% of adjudicated youth and the balance from the high school drop-out group. In addition, 25%of the total group was Native American (Chippewa Tribe), ages 16-21, with a 25% female population.

The operational plan designated the Employment and Training Agency (C.E.T.A.) responsible for the initial client intake process through referrals from the Sault Ste. Marie Area Public Schools, the Chippewa County Department of Social Services, the County Courts (District and Juvenile), and Community Action Agency. Each client was given an educational assessment text as well as aptitude, interest, and skill assessment. Initially, 40 youth were processed through intake and through a selection committee process, with input from the various community cooperating agencies a core of 16 youth were selected for the program. Eight youth were selected as alternates for any vacancies that might occur. (At the conclusion of the program 4 alternates were included and concluded the program.)

The program was further designed to assure 50% of the participants to be at least 18 years of age thus assuring the possibility of enrollment into an on-the-job training program at the conclusion of the Triple E program. (This was to alleviate concerns of the employers in hiring youth, and second, to alleviate potential problems concerning workers' compensation, insurance, Occupational and Safety Laws, etcetera.)

In order to achieve the program goals and objectives, the program was designed for twenty-two weeks, which was composed of thirty-one (31) hours per week for work experience, nine (9) hours a week of classroom training. In addition, an on-the-job training contract with local contractors to pay at least 15% above the minimum wage for a twenty-six week period was designed to complete the program.

In our efforts to achieve our second objective of academic/educational growth in the basic reading, writing, and arithmetic skills, high school completed credit was awarded to those participants who completed 100% of the classroom training portion of the program.

Weatherization and the energy conservation rehabilitation of one hundred twenty-six (126) homes in the community was completed through the cooperation of the Community Action Agency. Eligible families received services that included repairing storm windows, storm doors, insulation, caulking, etc.

Classroom training consisted of fifteen hours of introduction to safety and the operation of tools and equipment; twelve hours per week in weatherization and energy conservation, two and one half hours per week in basic arithmetic, remedial English, and employability skills.

All supportive services provided to the youth in terms of intake, assessment, and testing prior to the execution of the Triple E program were borne by the local agencies involved. However, some funds from the Demonstration grant were used for transporting the participants from classroom training sites to work experience sites.

On-going management of the project was assumed by the cooperating agencies and bi-weekly sessions were held for coordination, monitoring, updating, and on-going evaluation. During the course of the academic program and vocational classroom training portion, a safety instructor, a basic academic instructor, and an energy education consultant were employed. These individuals worked with the participants for the full twenty-two weeks of the program on a weekly basis.

Using such methods as discussions, lectures, simulations, worksheets, audio-visuals, demonstrations, hand-outs, guest speakers, and field trips, the energy education/conservation message covered weatherization, solid, liquid, and gas fuels, electricity, nuclear, and solar energy. Home conservation and weatherization took on special meaning for each of the participants as they were required to complete a passive solar panel that could be retrofited to their own dwelling. The core instructor assisted in the design and construction of these special student projects.

The classroom training results reflected a positive shift towards energy attitude and energy knowledge. Using a variety of testing instruments, including pre-and post-tests in order to compute an overall program rating the following steps were initiated. First, each student's pre and post tests were compared, and net change was recorded. This change was converted to a percentage and an average of the total scores was computed thus reflecting a class average. However, the basic core objective "to develop an energy conservation ethic and to increase knowledge and skills in energy conservation" was our program's highest priority. To provide the necessary expertise and resources to attain this objective, the services of an Energy Consultant were contracted. Briefly, these services would include consultation with the basic core Triple E instructor, formulation of course work, lecturing, evaluation of specific energy knowledge and inspection of site work to insure proper weatherization techniques and progress. To stimulate the participants' interests a mixed format of formal lecture was interspersed with a combination of audio-visual aids and discussion.

Weatherization and conservation techniques were stressed in the classroom with energy conservation being presented as the most reasonable and viable solution to our current energy crisis. Alternative energy methods were presented encompassing both their positive aspects and the problems that are incurred with their implementation — to again stress the need for conservation.

The Energy Option Survey reflected a ten per cent growth while recognizing that 70% of the participants at the beginning of the program discussing and demonstrating such techniques as infiltration reduction, ventilation, and insulation and incidental repairs necessary to ensure preservation of weatherization materials. (This type of assistance proved most beneficial since the majority of the 126 homes serviced were about ninety years old.) In efforts to develop and evaluate the energy knowledge gained by the participants, the Energy Consultant utilized four energy related tests: Energy Attitude Survey, Energy Quotient Test, Youth Energy Survey and Energy Review. The Energy Quotient Test results indicated a 30% gain in energy and energy conservation knowledge while the Energy Review posted a 20% growth between pre and post testing.
The Energy Opinion Survey reflecting a ten per cent growth while recognizing that 70% of the participants at the beginning of the program indicated they were already "doing something" in the form of energy conservation. The Youth Energy Survey reflected a 17% shift towards energy conservation and the conservation ethic.

Conclusion

Academically, the participants were able to: receive high school completion credit (82%); receive a high school diploma (or its equivalent - 6%); and receive vocational education certificates in weatherization (100%). In addition 60% of the participants were certified in power tools. Fifty percent of the participants recorded reading improvement, while 33% recorded improvement in basic arithmetic computational skills. Upon completion of the program 50% were placed into gainful energy related employment, 6% went on to school to further their education, 34% were turn-keyed to another training program while the remainder left the area to seek employment elsewhere or join the military service. Since the completion of the program not one of the participants has made an appearance in court.

SESSION 24: ADVANCED TECHNICAL SUBJECTS

24.1

ENERGY: SUCCESSES and FAILURES

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Abstract
Energy models have been developed and used for a variety of purposes, especially after the oil price increases. There is considerable speculation on the merits of energy models, especially as tools in aiding decision making.
Energy models can be broadly classified as operational models and analytical models. Operational models have been successfully in decision environments where specific issues are involved, such as investment planning, R and D planning, operations of complex energy systems, etc. Analytical models, which have been developed primarily for the purpose of "explaining" or "predicting" behaviour modes have not been as successful. Despite its shortcomings, energy modelling is still an efficient means of improving our understanding of the real world. Major areas where development work is required are:

* Better recognition of essential elements of energy systems
* Improved methods of aggregating the data
* Devising means of incorporating dynamism in model objectives
* Standardization of handling conflicting system objectives

Examples are provided to illustrate both the succeeding and the failing espects of energy systems modelling.

Objective and Scope
Recent years have witnessed a literal explosion in terms of the development of energy models. The driving force behind this great effort has been the rising oil prices, with the subsequent worldwide inflation. Since energy prices maintain their upward trend, it is quite likely that the interest and involvement in energy modelling will persist.

While work on energy models continue, it is appropriate to pause and take a critical look on what has so far been achieved. My objective here is essentially an exposition and evaluation of the major contributions and inadequancies of energy models. Since energy enters into every conceivable economic and technological process, and since models have been developed for most of these activities, I will have to be rather selective in choosing the areas for which models have been developed and applied.

Introduction
Energy models have been developed for a variety of purposes and applications. Examples of such models can be found in areas involving:

* The determination of the optimum mix of crude oils in a refinery (or a combination of refineries) in order to satisfy demand in the market for various oil products.
* The development of investment programs for the expansion of an interconnected system of power plants.
* Forecasting the regional demand for electricity and other energy carriers such as city gas, solid and liquid fuels.
* Estimating the impact on the economy (growth rate in GNP, rate of inflation, etc.) of an increase in crude oil prices.
* Predicting the short term or the long term price of crude oil in the international market.
* The establishment of a national energy policy for the long term.
* The analysis of global economic and technological developments in order to observe the impacts of different scenarios on future energy systems.

The examples given here are by no means exhaustive; they are selected merely to show the broad range of application areas that include micro level planning, sectoral, national, regional and global analyses and planning for a single fuel, or for all elements of the energy systems.

As far as mathematical formulation is concerned, the spectrum is no less varied. Almost every conceivable mathematical tool has been utilized, and new tools have also been developed in order to cope with the problems encountered. Econometric techniques are probably the most widely used, followed by linear programming, input/output techniques, mathematical simulation, control theory, nonlinear programming, etc. Among the new techniques that have been developed are: An input/output model with 'flexible' coefficients; a nonlinear optimiztion model based an quadratic programming, but with nonlinear technology coefficients in the constraints; a new search method; etc. (1).

'Apparent' motives in developing energy models may be grouped under the following headings:

* Analysis
* Forecasting
* Prediction
* Design

The word apparent has been put in quotation marks, mainly because the *stated* objectives and the *ultimate* objectives in developing or using energy models are usually quite different. For example, the stated objective of an energy model may be the 'design' of a gas supply system. A considerable effort is spent in indentifying system objectives, collecting the relevant data, modelling the system, and finding solutions which are belived to be either 'optimal' or at least 'feasible'. However, when the implemantation phase is reached, the numerical values obtained from the model output are seldom directly used. The model results may certainly have a bearing on the final decisions but are rarely taken from a computer output. There is almost always an 'interface' between the model and the actual use of the model. The ultimate objective in energy modelling almost always turns out to be 'education', be it the education of the modeller, that of the user, or both.

The existence of an interface is always necessary. After all, the exprience and judgement of an analyst are indispensible. On the other hand, the model itself may or may not be considered indispensible. Experience during the past 8-10 years has shown that in certain cases, formal (energy) models could make a significant contribution to healthy decisions. While in other cases they have been considered to have little value, if any. As a matter of fact, there even seems to be disagreement as to the extent to which models have been instrumental in actual decisions. Some claim that "too much faith is put on energy models" (2), while most systems analysts believe that not enough use is made of energy models! Most conferences and seminars on energy modelling include a session devoted to discussing "difficulties in implementation" where O.R. analysts usually complain from a lack of interest in actual uses of models. During such a session in a conference at the Interantional Institute for Applied Systems Analysis (IIASA) someone in the audience asked the 'modellers' on the panel if *they* had ever used a model to analyse their own energy systems problems. Only one of them answered in the affirmative! (3).

As is the case in most disputes, there is probably some truth on both sides of the argument. One thing is certain, however, and that is the fact that models have contributed significantly towards our understanding of complex energy systems.

Success in Modelling

In certain fields of energy systems analysis, modellers have succeeded in capturing the essence of the problem and aiding the decision makers with their models. The "flow network" type of model developed by K. Hoffman at the Brookhaven National Laboratory, for example, has been very useful in exposing the significant losses in a national energy system and in focusing attention to the weak links in the system. That model essentially represents major energy transfers from the primary energy resources all the way to the final uses of energy (4). The same model in lineary programming (LP) format has been used in establishing R and D priorities.

Process simulations in energy conversion facilities such as refineries or electrical power plants have also met with success. Considerable improvement in system design and operation may be achieved by better analysis through the use of computer models of such systems.

A mathematical programming model we have developed at Bogazici University has been used on several occasions. The model represented the national energy system in such a way that practically all energy investment possibilities were covered for the next 20-year period. (5). The model was first used in assessing the consistency of the energy sector in the Fourth Five-Year Plan (6). Later, it was used in generating plausible scenarios for the development of nuclear energy in the Turkish electrical supply system (7,8).

A search through the literature will reveal quite a few instances where formal models have been successfully developed and used, either directly or indirectly.

Difficulties in Modeling

Although it is impossible to categorize all successes or failures under one or two headings, it is quite possible to generalize on the set of circumstances that may provide a suitabale environment for successful modelling. A well-defined system objective, a simple *modus operandi*, and a short time horizon usually ensure success in model development and implementation. Departure from these characteristics, on the other hand, usually lead to great difficulties in implementation. Unfortunately, the more important and interesting energy problems are those that are inherently difficult to model. Two examples are given that illustrate some of the difficulties in modelling.

The World Petroleum Market

Petroleum prices are now closely watched by almost everyone. While the histogram of oil prices is common knowledge, future prices are a matter of conjecture. In a subject that is obviously so important, many attempts have been made that try to model the oil market and explain the emerging petroleum prices (9).

It is possible to base a world oil model on the assumption of cartel pricing, with the objective of maximizing revenue. Expressed very crudely, the revenue (R) is defined as

$$R = Q \quad P$$

where Q is quantity and P is price. The revenue can be expressed either as a function of price, or as a function of quantity. The cartel, therefore, can either set a price trajectory or a quantity trajectory; but not both. Since the objective is maximization of cartel revenue, it is possible to compute optimal prices and quantities, given the elasticities of demand.

The question is: how realastic would the results of such a model be? The answer is plainly: *not* very. A recent analysis (10) of seven major OECD countries covering the past 20 years indicates that the price elasticity of energy in the short run (1 year) is around -0.1 while that for the long run (8 years) is roughly -0.4 The use of constant elasticities in the model would yield optimal cartel prices well in excess of $100/barrel. With such quantum jumps in price, even the concept of 'elasticity' loses its meaning since that concept is related with marginal analysis. Borrowing an analogy from mechanics, it would then be more correct to talk of 'plasticity' of the response.

A modified version of this model is that of 'profit maximization'. In this case, a term that reflects the production costs per unit output is added. This term, however, plays only a minor role since production costs of OPEC are generally insignificant compared with prices.

It is possible to construct models related with certain postulates of OPEC behaviour. One of these is based on the notion that OPEC as a whole behaves as a 'satisfier', trying to achieve a certain revenue, usually assumed to be related to pre-determined income expections. 'Absorptive capacity' models can be considered within this class where OPEC countries are assumed to set target revenues as part of their development plans and consumption level predictions. The underlying assumption is again cartel behaviour, with either prices or quantities set by the supplier.

These models can be successful in explaining oil prices in only a limited number of cases, as large deviations have been observed between national plans and oil incomes. Further, they fail to explain the two-tier price structure of recent years.

OPEC can also be postulated as a 'long run economic optimizer'. In this case, OPEC is seen as trying to maximize a discounted sum of profits over a certain time horizon. Optimal strategy would be to raise prices with a large jump and to leave it constant for a number of years. In this way, the cartel would be taking advantage of low short run price elasticity. While discouraging the development of alternative fuel technologies by holding prices constant. As a matter of fact, the quadrupling of oil prices in 1973/74 followed by a period of five years within which prices were increased only to counteract the inflation of the dollar seemed to verify the result of such a model. However, the model fails to explain the recent continuous upward trend and the two-tier price structure.

The results of a simulation model of the world oil market seem to indicate that the long run revenues of the oil cartel are rather insensitive to the price of oil (11). In this model where fuel technology alternatives have also been modelled, a slow increase in oil prices delay the development of the alternatives, thereby making it possible to raise oil prices to very high levels alter. In contrast, early oil price increases cause the alternatives to be competitive earlier, thus lowering the ceiling to which oil prices can be raised in the future. Using reasonable discount rates of around 6-8% p.a., computations show that the total profit secured is more or less invariant to the strategy followed.

The implied results of this model are in sharp contrast with the results obtainable from short run or long run economic optimization models. If economic benefit is indeed invariant to the pricing strategy of the cartel, then it is imperative that the political forces at work be captured within the framework of any model that addresses the problem of oil prices. When this is done, one has to consider three groups of actors:a) the consumers; b) the producers; c) the traders.

Among the consumers, the industrialized free market economies constitute by far the largest and most significant group. The socialist block does not play an influential role, as by and large they are self-sufficient in energy. The developing countries do not seem to affect the market, either.

Among the suppliers, OPEC clearly dominates the market. However, it is no longer possible to treat OPEC as a single entitity, since Saudi Arabia claims dominance, hence her interests are not identical to the rest of OPEC's. This seems to be basic reason for the emergence of the two tier price structure.

The traders include the so-called 'major', the 'independents', and national petroleum companies. Prior to 1973, the majors played the dominant role. However, they are rapidly losing ground to the national oil companies in terms of the quantities of oil they handle. Whereas 60% of OPEC oil went through the majors in 1973, this has dropped to only 30% in 1979. Their economic strength, however, has since increased, not decreased, since the value of that 30% is considerably greater than the 60% of several years ago. Besides their economic strength, the majors control considerable refining, cracking, and storage capacity, which allow them to absorb even large shocks that can occur within the system.

In short, any O.R. analysis that attempts to explain the oil market must identify in this model every significant actor, as well as the objectives of each actor. It must also be understood that the cast or their roles are subject to change, as we witnessed in the case of Iran. Therefore, if a model is to explain market behaviour over an extended time period, it would probably have to rely on luck more than anything else.

Power Systems Planning

Another important field that deserves careful study by O.R. analysts is power systems planning. Expansion rates in the range of 10-15% per annum and costs in the vicinity of $ 10^9 per power plant indicate the great importance of system planning.

Until a few years ago, decisions in power systems planning was the responsibility of central electricity generating authorities, with *ad hoc* outside influences. The basic objective was economic optimization, subject to certain technical considerations, with environmental and social factors treated perfunctorily. Today, this picture is changing very rapidly and decision making is becoming extremely complicated.

Two major factors contributed to the change. One of these is the dominating influence built into laws and by-laws concerning the erection and operation of power plants. The other is the dramatic shift of authority in final decisions, as evidenced by plescibites in Austria, Federal Republic of Germany, and Sweden. As a result, today's decision making involves various actors and several objectives. Furthermore, some of the objectives are difficult to define, let alone quantify. Financial objectives probably will always play an important role, but environmental factors and *perceived* risks seem to be other major determinants. Clearly, a new approch which models these objectives and the decision making process is called for.

Despite considerable efforts to date, a general model that copes with multiple objectives does not exist. Present methods can be classified in two groups.

(1) Techniques which rely on prior specification of preferences;
(2) Techniques which rely on progressive articulation of preferences (12).

Even the latter method implies that certain decision are taken *before* the final solution has been arrived at. While *a priori* articulation of preferences may result in sub-optimal decisions, deferring the decisions until after all the solutions are obtained would clearly lead to a selection from an overwhelmingly large number of alternatives. A compromise has to be struck between *a priori* decisions and a complex decision process. The greater the number of objectives and the complexity of the model, the more difficult it is to find solutions and to choose among them.

Modelling Physical vs Social Systems

As should be apperent from the examples given, it is the *social* aspects of energy systems that make modelling difficult, not the physical or the technological. Two basic characteristics of socioeconomic systems are 'complexity' and 'dynamism'. The sheer magnitude of the number of variables that influence system behaviour make such systems *complex.* Furthermore, the basic characteristics of these systems change over time, making them *dynamic* (13). The phrase "nothing is permanent but change" summarizes the situation beautifully.

The fact that a large number of variables influences the behaviour of the system requires that we recognize the essential elements of the system and model only those. On the other hand, a changing system requires that new elements may have to enter if the model in system behaviour is to be representative of the reality. This aspect of energy modelling is one of the most elusive in problems involving long range planning.

Everything discussed so a is applicable only when the objectives remain invariant to system response. In real systems, however, the response of the system (or the outcome of whatever is being modelled) causes certain changes which may influence the very reasons for the emergence of those outcomes themselves. A good example of this type of behaviour has recently been observed in the case of nuclear energy. Energy strategies based on economic and tehnological efficiency which led to the rapid expansion of nuclear energy were met with forces that paid greater importance to environmental, social or psychological factors. The reason for the moratorium on nuclear energy in several countries is attributable to a change in priorities or objectives.

As a matter of fact, 1970'ies have witnessed considerable calibration and tuning in models in order to make them produce consistent results. The emergence of the environmentalists and the pursuit of a 'clean' environment is only one of the new social objectives. The so-called 'oil embargo' was another incident -real or imaginary- that has prompted many industrialized nations to stockpile petroleum. The move was a clear incident of conflicting objectives in energy planning, since oil prices rose in response to this increased demand, resulting in a sacrifice in economic efficiency in return for security of energy supplies.

Clearly, in energy systems not only is there more than one objective, but there is considerable dynamism among the objectives. The problem that remains is that of modelling the interaction between system response and system objectives.

Modern system theory is essentially based on the interactions between the system and its environment. Systems are grouped in terms of these interactions as follows (14):

(i) Extensive Function: Systems that are uninfluenced by a changing environment exibit 'extensive function'.
(ii) Intensive Function: Systems that respond to changes in their environment show 'intensive function'.
(iii) Purposive Behaviour: Systems that change their behaviour when no apparent change in their environment has taken place exhibit 'purposive behaviour'.

If we assume that the response of the system has actually caused changes in its environment, then the observed shifts in objectives can be explained in terms of intensive function. On the other hand, if the changes in ojectives have taken place without any changes in the environment, then we could call this purposive behaviour. Viewed in this way, and assuming that the environmentalist movement has gained acceptance as a result of evidence of physical degradation, this response could be explained in terms of intensive function. The nuclear issue, however, is not based on any significant physical damage, and may therefore be defined as purposive behaviour.

A fourth category may also be created that explains the changes in the objectives. That category could be termed 'learning behaviour' and would refer to those cases where system objectives change as a result of *system response*, rather than changes in its environment.

A system may 'learn' in many different ways. One of these is by studying itself. Any theory that attempts to explain the behaviour of the system may actually influence the behaviour of that very system. For example, most people are aware of economic theories that relate government spending, inflation rates and unemployment. By following the policies closely, people develop expectations about likely developments in the market and change their behaviour accordingly. Such (learned) behaviour has made classical theories of consumer behaviour useless and new theories are being developed, that are called, appropriately enough, 'rational expectations'. If these new theories find acceptance and when they are widely known, they will also be replaced by other theories!

Conclusions

Considerable success has been achieved in building and using 'operational' energy models. The same degree of success has not been observed in models built for the analysis of certain problems or in planning future energy systems. The underlying causes of the failure stem from the socioeconomic aspects of energy systems problems.

The great complexity and dynamism of such systems call for a completely new approach in modelling energy systems. The major areas where research work is required are:

* Better tools for the recognition of essential elements of the system being studied, and for the recognition of changes in system elements.
* Methods for systematically aggregating the data in an effort to reduce model size and arrive at compact, easy to use models.
* Methods for handling several, even conflicting system ojectives within the modelling framework.
* Means of incorporating dynamism in model structure in such a way that not only system objectives may undergo change, but also the learning effect may also be built into the model.

We should also recognize that we can never hope to build a model "once and for all", but try to build models that 'develop', much like the environment they try to represent.

References

1. A number of books are available, where "energy modelling" is covered in detail. See, for example:

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   * M.F. Searly (Ed.), *Energy Modelling*, R.F.F., Wash., D.C., 1973.

   * I. Kavrakoglu (Ed.), *Mathematical Modelling of Energy Systems*, Sijthoff and Noordhoff, Holland, 1981.

2. R. Stobaugh and D. Yergin (Ed. s), in their book *Energy Future* claim that model results have a significant bearing on what Washington decides to do. They also believe that models have been instrumental in shaping the public opinion as well as the private sector.

3. Conference on the "Modelling of Large Scale Energy Systems", IIASA, Laxenburg, Austria, Feb. 1980.

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9. I. Kavrakoglu, "Crude Oil Prices: Panel Discussion", *Mathematical Modelling of Energy Systems,* pp. 459-476, Sijthoff and Noordhof, Holland, 1980.

10. G.J. Kouris, "Energy Modelling: The Economists Approach", in ref. 8.

11. L.K. Ervik, "Choice of Modelling Technique: An Example of a Simulation Model for World Oil Supply and Demand", pp. 274-277 in Reference 9.

12. J.L. Cohon, D.H. Marks, "A Review and Evaluation of Multiobjective Programming Techniques", *Water Resources Research,* 11, 2, pp. 208-220, 1975.

13. The term dynamic as used here does not have the same meaning as used for physical systems where motion may take place but the system itself does not lose its identity. A certain class of systems, 'adaptive' systems, may exhibit changes in system structure, but such changes are built in to the system externally; the system does not by itself create rules of redefining itself, but socioeconomic systems do.

24.2

ENERGY EDUCATION WITHIN AN ENVIRONMENTAL RESOURCES ENGINEERING PROGRAM

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Abstract
This paper describes three energy courses which have been developed as part of an undergraduate program in Environmental Resources Engineering at Humboldt State University. The program comprises basic coursework in the physical, biological and engineering sciences and emphasizes fundamentals of design and analysis associated with environmental and resource related problems. Each student must complete 26 quarter units of upper division courses organized into a coherent major emphais option. the courses described, Energy Systems Engineering I, II and III, form the core of the major emphasis option entitled Energy Resources. Subject coverage in these courses includes thermodynamics relevant to energy systems, global energy resources, conventional power generation techniques, solar, wind and geothermal power production, and future energy systems such as OTEC, hydrogen fusion, and MHD. This coverage is detailed along with laboratory exercises and design projects. Curriculum materials such as texts, reference sources, media aids, and class handouts are also presented. The description concludes with an analysis of how this sequence intergrates with other courses, both within and outside engineering, to form the Energy Resources Option. Educational goals of the option are discussed and representative student programs are presented as examples of how these goals are being addressed.

The engineering program at Humboldt State University (HSU) is an unconventional one. Although many of the courses and educational rationales are similar or even identical to traditional ones, there are important differences. There are several reasons for this. First and foremost is the fact that the program is solely environmental in nature and is not (as are most environmental programs) an adjunct to a civil engineering program. Operationally, this means that some courses which would ordinarily be required are not and that they are replaced by others not normally taken by engineers. Another noteworthy difference is the fact that the Engineering Department at Humboldt is just that: a department, not a school of engineering. The department is a member of the School of Science along with the sciences, Math, Industrial Arts and Technology, and such unrelated disciplines as Nursing and Home Economics. The department's membership in the School of Science imposes constraints on resources and direction not normally felt in engineering education (such as competing with the sciences for funds), but also frees the department from some of the traditional roles of an engineering school. Finally, there are time constraints produced by the additional environmentally oriented courses. It is always difficult to prepare a student professionally in four years of conventional engineering education; these extra courses make professional preparation that much more difficult. This results in a larger number of required courses than is common in an undergraduate program.

The Program
Course requirements for a Bachelor of Science in Environmental Resources Engineering are given in Appendix A. Noteworthy as courses not normally required of engineering students are Biology. Ecology and Ecology Lab, Technology and Man's Environment (an introduction to environmental engineering), Systems Analysis, and Environmental Impact Reports. A year long senior project is also required.

The bulk of senior level work is organized into a coherent program comprizing 26 additional quarter units called the Major Emphasis Option. Students are free to choose among four options: Energy Resources, Water Resources, Water Quality, and Geotechnical Engineering. Within each option, three design courses are specified and the remaining units are elective; they are chosen by the student in consultation with a faculty advisior. At least one course within the option must come from outside the School of Science.

The Energy Resources Option
The purpose of the Energy Resources Option is to prepare students to do design work with energy systems and to build an awareness of how energy technologies and policies affect global energy resources and environmental quality. The three required design courses, the core of the option, are Energy Systems Engineering I, II, and III.

An outline of the curriculum of these courses is found in Appendix B. The overall rationale of the sequence is to examine first conventional energy production systems and then to move on to more futuristic ways of generating power. Since solar thermal technologies are judged to have a special importance to environmental engineers, the final course is devoted solely to these considerations.

The sequence begins with an overview of global energy use rates and resources. This is followed by an extensive section of thermodynamics relevant to energy systems. The focus is the 2nd Law, irreversibility, lost work, and the definition and use of the concept of 2nd Law efficiency (1). The purpose of this section is to provide a principled foundation for design techniqus which follow.

Principal present energy generation systems are then studied. Conventional steam and gas turbine cycles are examined along with various refinements which have been developed over the years to increase efficiency. This leads into a study of nuclear generation facilities. The first course concludes with a section on geothermal and hydro power. Environmental impacts of each generation systems are stressed as each is studied.

Since HSU is located conveniently close by the Geysers Geothermal Power Plant, last year's class traveled to that Pacific Gas and Electric facility. Based on the trip and on class material, students were asked to write an essay (Appendix B) in which they contrasted the pros and cons of a large geothermal power plant relative to a fossil fueled one. Both the reliability of the energy source and the environmental impacts were considered in the essay. In this way, students were forced to examine the type of policy decisions faced by energy management personnel.

The second course covers photovoltaic cells, wind turbines, fusion power shcemes, and fuel cells. When time and interest permit, megnetohydrodynamic (MHD) and ocean thermal energy conversion (OTEC) schemes are also covered. For all these topics the development is similar. Physical principles underlying each technique are studied, the physical generation equipment is descrbed, and criteria are developed to enable the student to complete design calculations.

A second field trip is undertaken; Lawrence Livermore Lab was the site of this Spring's trip. Students viewed the Lab's state of the art fusion research effort and experienced the complexity and expense associated with such a difficult undertaking. They were again asked to write an essay (Appendix B) detailing and justifying their views about the ultimate success of fusion as a power source.

No textbook adequately covers the material in these two courses. The best compromise at present seems to be Krenz's book (2), "Energy: Conversion and Utilization" which has been adopted as the text. Since Krenz's discussions are often lacking in specific details, various supplementary sources are also used (Appendix B). For laboratory assignments, no textbook exists. Assignments are written by the instructor and disbributed as mimeo handouts.

The third and final course covers solar thermal technologies. Of the three, this course is the most conventional. An excellent text, Lunde's "Solar Thermal Engineering" (3) is used throughout and the development closely parallels that of the text. Heat loss calculations, solar radiation assessment, flat plate collector design, system integration, performance, and economics, and passive system principles form the topics of the course. A listing of lab exercies and an example of a student design problem are given in Appendix B.

Representative Student Programs
The courses just described comprise 12 of the 26 required quarter units in the Energy Resources Option. Students choose the remaining 14 units in such a way as to tailor the option to their interests. The following three student programs demonstrate some possibilities. Joe Brezner is interested in the measurement and control of energy systems. Included in his option are: Transfer and Rate Processes, Applied Numerical Analysis, Electronic Instrumentation, and Microprocessor Electronics. A political science course, Politics of Resource Development rounds out his program. Political and social implications of energy policy are a main concern of Richrd Corsi. He has chosen Transfer and Rate Processes, Analysis of Environmental Impacts (a continuation of Environmental Impact Reports), Advanced Engineering Mathematics II, and the same political science course as Joe to fill his option. George Havens has a special interest in passive solar technologies. His program includes: Structural Analysis, Structural Design, Architectural Drafting, and an intriguing pyschology course, Human Factors in Environmental Design. These are three of the many possibilities available to students in the Major Emphasis Option. The engineering faculty is liberal in allowing students freedom of choice within their option. The primary criterion for acceptance is a demonstration by the student that the program is coherent, rigorous, and beneficial to his or her career goals.

Since this program is new (the complete sequence was taught for the first time this past academic year), no students have yet graduated with this training. Of the students above, Joe is spending the summer sa a research assistant on a remote sensing experiment in Humboldt Bay and Richrd is working as a student intern with the government lab at Hanford Washington.

Students who have graduated from the older Energy Resources Option (which was less developed than the one described) have had no trouble continuing their careers. Some have gone to graduate school, some to public and private engineering firms. One student works with the Bonneville Power Administration, another is a local solar consultant, and a third is developing a 60,000 square foot solar collection system for a wastewater treatment plant in Alabama. So, though this program is unconventional, it attracts students in increasing numbers and serves their professional needs.

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2. J.H. Krenz, ENERGY: CONVERSION AND UTILIZATION, Allyn and Bacon, Inc., Boston, 1976.
3. P.J. Lunde, SOLAR THERMAL ENGINEERING, John Wiley and Sons, New York, 1980.

Appendix A: Requirements for the Bachelor of Science in Environ-Resources Engineering at Humboldt State University

1. General Education and Statutory Requirements, 76 quarter units.

2. Major Lower Division Requirements, 60 quarter units.

Course	Quarter Units
General Chemistry (CHEM 1A)	4
General Chemistry (CHEM 1B)	
	5
General Chemistry (CHEM 1C)	5
Principles of Biology (BIOL 3)	5
Elementary Analysis (MATH 2B)	4
Elementary Analysis (MATH 2B)	4
Elementary Analysis (MATH 2C)	
Elementary Analysis (MATH 2D)	
	4
Elementary Analysis (MATH 2E)	4
General Physics (PHYX 4A)	4
General Physics (PHYX 4C)	4
General Physics (PHYX 4D)	4
Introduction to Design (ENGR 1)	4
Introduction of FORTRAN programming (ENGR 2)	3
Technology and Man's Environment (ENGR 11)	4
Solid Mechanics: Statics (ENGR 30)	4
Solid Mechanics: Dynamics (ENGR 31)	4
Materials Science (ENGR 45)	4

3. Major Upper Division Requirements, 56 quarter units.

Course	Quarter Units
Principles of Ecology (BIOL 106)	3
Ecology Laboratory (BIOL 107)	1
Advanced Mathematics I (MATH 110A)	4
Engineering Economics (ENGR 100)	3
Advanced FORTRAN for Engineers (ENGRE 102)	3
Mechanics of Materials (ENGR 110)	5
Thermodynamics (ENGR 110)	4
Fluid Mechanics I (ENGR 113)	3
Fluid Mechanics II (ENGR 114)	3
Electronics & Instrumentation (ENGR 120)	4
Probability & Statistics I (ENGR 123)	3
Probability & Statistics II (ENGR 124)	3
Systems Analysis (ENGR 125)	3
Environmental Impact Reports (ENGR 180)	3
Senior Project (ENGR 196A,B,C)	3

Appendix B: Curriculum Outline

Energy Systems Engineering I

I. World Energy Resources
- a) Distribution, recovery
- b) Use rates, exponential growth

II. Thermodynamics of Energy Systems
- a) 1st Law
  1. Conservation of energy, 1st Law efficiency
- b) 2nd Law
  1. Entropy, irreversibility, spontaneity
  2. Lost work, 2nd Law efficiency

III. Conventional Power Generation
- a) Fossil fuel: gas, oil, coal
  1. Combustion thermochemistry
  2. Direct uses: heating, internal combustion and steam engines
  3. Conversion to electricity: steam and gas turbines, transmission and storage
  4. Environmental impacts
- b) Nuclear fuel: Uranium, plutonium
  1. Nuclear physics, binding energy
  2. Nuclear plants, boiling water and pressurized water reactors, breeders
  3. Safety, waste disposal, environmental impacts

IV. Geothermal Energy
- a) Geothermal activity, distribution, resoruce assessment
- b) Conversion ot electricity
- c) Environmental Impacts

V. Laboratory Exercises
- a) Caloric values of fuels by bomb calorimetry
  1. Gasoline
  2. Wood
  3. Coal
  4. Food
  5. Methanol
- b) Factors affecting the coefficient of performance of a refrigeration cycle
- c) Efficiency of a Pelton Wheel
- d) Geysers Field Trip

Text

Krenz (Reference #2)

Supplementary Materials

Ford, et. al. (Reference #1)

G. Brown, HYDROELECTRIC ENGINEERING PRACTICE, Blackie and Son, Ltd, London, 1964.

A. Bartlett, FORGOTTEN FUNDAMENTALS OF THE ENERGY CRISIS (an excellent videotape).

Student Assignment, Geysers Field Trip Report

You are a consulting engineer for Humboldt Power and Light Co. A decision must be made as to how the company should provide an additional 1 GW of generating capacity. There are two possibilities:

1) The company has discovered a geothermal field nearly identical to the Geysers Field in a rugged area of the Trinity Alps of northern California. This field could be developed in a manner similar to the Geysers Field.

2) A contract could be negotiated to buy coal from Utah and have it shipped by rail to the northern Sacramento Valley where a 1GW coal fired generating facility would be built and operated.

Write an essay of 800-1000 words critically analyzing this choice. Explain what criteria you would use in making the decision including the relative weight you would assign to each.

Energy Systems Engineering II

I. Photovoltaic Cells
- a) Semicnoductor physics, limitations of efficiency
- b) Materials, cell construction
- c) System design, energy storage, economics, environmental impacts

II. Wind Energy
- a) Wind assessment, power duration curves
- b) Power in the wind, Betz limit
- c) Turbine designs and characteristics
- d) System design, economics, environmental impacts

III. Hydrogen Fusion
- a) Nuclear physics, Lawson criterion
- b) Containment systems
- c) Laser systems
- d) Environmental impacts

IV. Fuel Cells
- a) Electrochemistry, chemical thermodynamics
- b) The H_2-O_2fuel cell
- c) Modern designs, efficiencies, economics
- d) Environmental impacts

V. Laboratory Exercises
- a) Efficiency and V-I characteristics of a solar panel
- b)Wind tunnel measurements on a vertical axis wind turbine
- c) Characteristics of a H_2-O_2 fuel cell
- d) Field trip to Lawrence Livermore Lab

Text

Krenz (Reference #2)

Supplementary Materials

S.S.L. Chang, ENERGY CONVERSION, Prentice Hall, Engle wood Cliffs, N.J., 1963

J.J. Loferski, J. Appl. Phys., *27*, 778 (1956)

J.P. Holdren, Nuclear Technology/Fusion, *1*, 79 (1981)

Student Assignment, Livermore Field Trip Report

You have now had the opportunity to study about the fusion process and to see one of the largest fusion research efforts. Fusion energy is being touted as the energy source of the future. The future is probably about 40-50 years away, a time when most of our petroleum reserves will be depleted.

Based on what you've learned and what you've seen, write an 800-1000 word essay explaining whether or not you think fusion will work. Specifically, will we be producing a significant portion of our power in 40-50 years using fusion reactors? Include in your essay an examination of the various factors which will influence whether or not fusion "works." Examples of such factors are scientific feasibility, technical feasibility, commercial viability, fuel procurement, safety considerations, environmental impacts, social and political concerns, etc.

Energy Systems Engineering III

I. Heat Loss
- a) Conduction, convection, radiation
- b) Degree days
- c) Structure heat loss calculations

II. Availability of Solar Energy
- a) Radiation measurement, solar constant
- b) Diffuse and direct beam radiation
- c) Clear day design values

III. Collection of Solar Energy
- a) Site selection, shading
- b) Flat Plate Collectors
  1. Materials, construction
  2. Tau-Alpha product,selective surfaces
  3. Fin efficiency, operating characteristics

IV. Active System Design
- a) Storage systems, heat exchangers
- b) Sizing
- c) Component integration, freeze protection
- d) Economics

V. Passive System Design
- a) Storage systems
  1. Trombe wall, rock bed
  2. Solar ponds
  3. Sizing
- b) Greenhouses, examples, economics

VI. Laboratory Exercises
- a) Measurement of the solar constant
- b) Thermal conductivity of collector absorber materials
- c) Efficiency of a flat plate collector

Text

Lunde (Reference #3)

Student Assignment, Design Problem

You are an engineer working for a large metal fabrication firm. Your firm is about to enter the solar collector absorber sheet market and has assigned you to determine the most cost effective design. Since your firm expects to manufacture a large volume of absorber sheets, the overriding cost will be the cost of materials. You have a choice of steel or copper. Copper costs $1.80 per pound; steel costs 23¢ per pound. The design your firm wishes to manufacture is the common tube on sheet absorber with tubes soldered or brazed to the sheet. The sheet is to be 4'x8'. Copper is available in sheet thicknesses of 0.005", 0.010", and 0.020". Steel sheet may be 0.020", 0.040", or 0.060" thick. All manifold pipes are 1.50" OD, 0.125" wall; all riser tubes are 0.375" OD, 0.0625" wall. Your absorber sheet should have as many riser tubes as necessary to produce a fin efficiency of 95%. The absorber must be all copper or all steel, and will be installed in a collector with an overall heat loss coefficient of U_L=1.40 Btu/hr-ft^{2}° F.

1. What is the most cost effective design?
2. Will the design change if a selective surface is used so that U_L is reduced to 0.85 Btu/hr-ft^{2}-° F?

(Thanks to Marshal Merriam for the idea for this problem)

24.3

CURRICULUM DEVELOPMENT FOR AND INSTRUCTION OF A GRADUATE LEVEL SOLAR ENERGY COURSE*

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Abstract

A graduate level curriculum for an applied solar energy technology course will be described. The curriculum includes detailed theory development and applications lessons on the five major solar energy technology areas (photovoltaics, solar thermal, wind, biomass, and ocean thermal energy conversion) along with more elementary lessons on solar resource assessment and measurement, solar economics, and the impact of the technological utilization of solar energy on life quality. arious aspects of curriculum construction, instructional

technique, and performance evaluation are described in detail including: text selection, homework, term projects, lesson planning, and pre/post-testing cycles. Finally, the first semester is viewed in retrospect based on student feedback from an anonymous evaluation questionaire.

Introduction

The world is faced with an energy problem of untold magnitude and duration. Solar energy technologies offer viable alternatives to fossil fuels and, as such, are attracting wide-spread interest at all levels of government, industry, and the civilian population. As the solar technologies grow and energy requirements, availability, and economics dictate the need for alternate energy sources, the community, state and nation will need highly trained people in the energy field. In an attempt to begin such a training or educational program at the Evening College Center of The Johns Hopkins University Applied Physics Laboratory, a first course in solar energy technology and applications[1] was offered during the fall semester of 1980-81 academic year.

The basic objective of the course was to present an overview of solar energy and to acquaint the students with the five major solar technologies (photovoltaics, solar thermal, wind, biomass and ocean thermal energy conversion). In addition, the curriculum was designed with enough flexibility to allow the peripheral but all important areas of resource assessment, solar economcis, solar materials science, and solar life impact to be fully addressed.

Textbook selection for the course was very difficult with no one book (except perhaps survey type handbooks) covering the full range of solar technology. The selected textbook: *Solar Energy Engineering*[2] by A.A.M. Sayigh was chosen as a book to compliment the instructors own knowledge, experience, and resources in solar energy. The text is strong in solar resource assessement, solar thermal, and energy storage. The instructor was strong in photovoltaics, solar economics, solar materials, and life (environmental) impact areas. The instructor also had access to information or some knowledge in biomass, wind, and ocean thermal energy conversion.

The Student Population

A. Student Demographics

Areas of demographic interest include student degree field, student present degree level, student classification, and student work positions. The student population held twenty engineering degrees out of a possible twenty-four and similarly thirteen out of nineteen individuals were employeed as engineers.

B. Student Solar Knowledge

In order to assess the student's pre-course solar knowledge, as detailed questionaire was circulated during the first class meeting. This questionnaire was set up to rank an individual's perceived solar knowledge on a zero to ten basis in several selected solar fields. The fields include: solar resource assessment, solar economics, solar materials, solar like (environmental) impact, geothermal and hydroelectric power (sometimes considered solar technologies), and the five major solar technologies - photovoltaics, solar thermal, wind, biomass, and ocean thermal energy conversion. Once the questionnaire was completed, a pre-test designed along similar lines of the questionnaire was administered to measure the students knowledge in the ten selected solar areas.

A combination of the results of the questionnaire and pre-test were used to structure the level and scope of the energy lessons to follow. The general assessment from the distribution of results was that the students had little pre-course knowledge in solar energy (over all average 2.4 with zero reflecting no knowledge and ten implies full working knowledge).

Curriculum Content

The curriculum content for the solar energy technologies course is one of the most varied and extensive possible in a single semester course because of the broad base of scientific and technological fields spanned by solar energy conversion. In fact, the combined disciplines of engineering, physics, chemistry, biological, earth and life sciences, and economics must be brought together in a unified fourteen week package.

Since certain broad principles of resource assessment, economics and life impact pervade all the solar technologies these were taught as initial overview lectures during the first few sessions of the course. Additional details on each of these areas was then treated during the individual solar topic lessons. Each major solar technological area was handled in a similar matter. The individual cell technologies and materials were delineated and assessed in order to aid the student in making future judgements about each technology option. The life impact analysis was treated as a general cost - benefits type of study in the general overview lecture. The general analysis was applied to the product life cycle (materials, manufacturing, deployment use, and decommissioning) for a photovoltaic energy system.

Each lesson plan was created with specific behavioral objectives in mind and specific homework assignments. Homework assignments were used to re-inforce classroom material, promote outside reading and to introduce additional subject material which could not be introduced in the classroom due to the limited schedule. In addition to specific homework assignments, students were given the opportunity of doing a term project report in lieu of taking a final exam. Most students (17 of 19) took advantage of this option with several excellent term papers being received. The term papers will be discussed in more detail below.

Student Performance

Four basic measures were used to assess student progress. These measures were homework, class participation, mid-term exam, and final exam or term report. Homework and class participation were graded on a subjective basis rather than on a strict quantitative measure. For example, homework was given a plus (meaning excellent) check (for satisfactory), and a minus (less than satisfactory, but turned in). A zero was reserved for pupils who failed to turn in assignments. Homework papers would be accepted up until two weeks prior to the end of the term.

The mid-term exam was prepared with the idea of testing the student's learning in each of the five preselected areas (photovoltaics, solar economics, life impact, resource assessment and materials) covered during the first half of the semester.

The students were free to select their own solar term paper topic. Topics had to be approved by the instructor by mid-term time. Paper length was nominally set at 2,500-5,000 words (ten to twenty type written pages excluding illustrations). Topics ranged from solar ponds to aspects of solar satellite power systems with many excellent reports. Most students received an A for their paper and the course.

Course Performance
Course-instructor performance was assessed through use of the standard evening college questionnaire[3]. The results were about average the college. Other courses taught by the instructor have had higher medians than the average which is probably a reflection on the wide diversity of information and disciplines encompassed by the solar technology course (compared to the other courses.) On the whole it appears that both the course and instructor did an adequate job in meeting student expectations and demands while imparting a reasonable amount of knowledge as evidenced by mid-term exam, final and term paper performance.

Summary
A graduate level curriculum has been developed for a one semester course on solar technology and applications. The curriculum emphasizes major solar areas including: solar ecnomics, life impact, resource assessment, materials and the five solar technological areas (photovoltaics, thermal, wind, biomass, and ocean thermal energy conversion). In teaching the curriculum several important items became apparent: 1) the initial student body although trained in engineering and the sciences had little basic knowledge of solar; 2) the curriculum seemed to match the basic demands of the students (based on improvement in student knowledge — mid-term, final) and interest in term paper; and 3) because of the wide scope of technology covered by the solar curriculum it was difficult to instruct.

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24.4

CAN WE STILL WIN THE 'ENERGY WAR'?

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Energy Committee of American Association of Engineering Societies

As the only profession which implements energy policies or strategies, engineers feel that they owe it to the public to share their concerns and convictions about needed national action. The following conclusions are excerpted from the position paper adopted on July 2, 1981, in Atlanta, GA:

1. Current news stories on "oil gluts" and slight price reductions should not lull us into a false sense of relaxation. Our future security and living standards still demand urgent steps.

2. Engineers (and leaders of the western industrial nations) still endorse education on energy efficiencies and conservation; this can gain us time to expand domestic resources, particularly coal and nuclear, and to accelerate development on synthetic fuels, solar, geothermal, fusion, etc. counterproductive price controls, rationing, overregulation and extremely costly delays must be avoided, without causing any sacrifice of safety, health or environment..

   However, in an expanding society, conservation and solar or renewables cannot possibly constitute the whole answer. Nor can free enterprise and market forces be relied upon, by themselves, to make up for lost time. Past and future government action will also be critica to our future "energy and economy" position.

3. Continuation of our 70-plus billion dollar annual oil imports (and imports of other strategic materials) endanger our national security and contribute to a major foreign trade deficit which continues to shrink our dollars and living standards. Many families in the US and abroad can no longer meet their essential needs for energy and for food.

4. Because we failed to prepare ourselves before or in the 1970s, econoics "stagflations" and crisis-by-crisis operations are likely to continue well into the early 1980s, in any case. The challenge is now to work for an improved outlook in the later 1980s and 1990s.

5. Longer-range world problems of still rising populations and demands for scarcer critical resources must be addressed, everywhere, if the spread of starvation is to be reversed.

6. Specifically and most urgently, we must reverse our position of being the only major industrial nation in a "nuclear retreat," cancelling more plants than we are ordering, placing our breeder and fuel recycle programs in limbo, and spending over twice as much time and money to build plants which are still under construction. Facilitating legislative and regulatory changes must now be adopted with a sense of urgency, and without sacrifice of safety.

7. Extremely costly, unjustified barriers and delays on the production and use of domestic resources—such as inflexible requirements to reestablish orginal ground contours or to wet-scrub stack emissions of coal—must also be modified.

8. Contingency plans must be developed to deal with sudden upheavals and interruptions in imports of oil and other highly critical materials.

9. Critical longer-range developments, such as nuclear breeders which extend the nuclear option from decades to thousands of years must be assured.

10. Finally, we in professional societies, educational systems and the media must live up to our responsibilities to avoid simplistic or wishful "gee whiz" solutions, and to educate the public to our realistic dangers, options and consequences. A properly informed

public is now vital to the needed decisions and actions of our leadership and our institutions. The continued viability of our system depends on it.

Moderator and presentor: R. Murray Campbell, Stone & Webster, Boston; and President, Mass. Voice of Energy.

Workshop-Discussion, evening of August 5, 1981:

24.5

A TECHNICAL COURSE SERIES IN APPLIED SOLAR ENERGY AT THE SENIOR/GRADUATE LEVEL

Ronald M. Cosby
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Abstract: A year long sequence of three courses in applied solar energy is offered at the senior level by the Department of Physics and Astronomy at Ball State University. The course series is designed primarily for physics majors with career interests in research and development in the solar industry. This paper describes the goals, organization, content, textual and computer aids, and the lab courseware for these applied technical courses. Improvements in the course syllabi, computational exercises, and laboratory hardware experiments which have resulted from experiences in developing and twice teaching this course sequence are detailed. The teaching strategy follows the broad outlines of component study, systems analysis, and specialized topics. Course one analyzes the solar resource and the optical, thermal, and mechanical components common to most solar thermal systems. The second course completes the components study and dwells on analyses of solar thermal systems synthesized from the studied components. Solar electrics, primarily photovoltaics, comprise the major study topic in the third course. Laboratory courseware has been developed for student experiments on a variety of topics, including solar insolation, properties of solar materials, solar collector performance, solar cells, and other.* Student application of commercially available computer software to system design and analysis and student development of software are also important course objectives, as computer simulation serves as a valuable tool in the solar industry.

* Laboratory courseware development supported by the National Science Foundation's Local Course Improvement Program.

24.6

CHEMICAL ENERGY STORAGE - A GRADUATE COURSE IN PHYSICAL CHEMISTRY.

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Abstract

Many schools of chemical engineering in Sweden are presently reviewing their curriculae with regard to pertinence in energy matters. One of the planned new courses at the Royal Institute of Technology is "Chemical energy storage". This course, intended for graduate students in chemistry, deals with basic principles and limitations on different means of storing energy.

Included are:

- thermodynamics of energy storage and conversion, availability analysis
- Thermochemical methods

latent storage, absorption process, chemical heat pumps, high temperature storage and transportation

- electrochemical methods

primary and secondary batteries, fuel cells

- photochemical methods

photosynthesis, photochemical fuels, solar cells

- thermal and mechanical methods
- resource analysis, environmental impact, future energy systems, hydrogen economy

The paper describes the goals and considerations behind the course and gives detailed information about its content.

SESSION 25: TARGETED PROGRAMS IN ENERGY AWARENESS, DESIGN, AND TRAINING

25.1

DESIGN OF PASSIVE SOLAR SYSTEMS
by
Donald L. Michelsen
Virginia Tech at Dulles
Washington, D.C.

Introduction

Virginia Tech has an active graduate program located at the Dulles International Airport complex in Virginia thirty miles from Washington, D.C. The Engineering Program at Dulles offers evening courses leading to Masters degrees in five areas -- Aerospace and Ocean Engineering, Civil Engineering (Analytical Photogrammetry and Remote Sensing), Electrical Engineering, Engineering Administration (Industrial Engineering and Operations Research), and Systems Engineering. Other program areas include Education, Business Administration, Economics, Computer Science, Public Administration and Policy, and Home Economics.

During the 1981 spring quarter (10 weeks) the author taught an elective special study (trial) graduate course entitled "The Design of Passive Solar Systems" meeting one night per week. A total of twelve professionals, all with full time jobs, were enrolled in the evening course (none with mechanical engineering degrees), but only 9 students finished the course. The course attracted enrollments age 20 to 55, from General Accounting Office, U.S. Air Force (Pentagon), Johnson Controls, Mobil Oil, Frederick Community College, N.A.S.A. (Goddard Center, Md.), Automata, U.S. Navy (Crystal City, Va.), Sigma Data Service Corporation, Harry Weese and Associates, and Davis, Smith, Carter & Rider (2 students). The eight with engineering degrees and one with an architecture degree completed the course.

The Course

TABLE I shows the course syllabus. The author made numerous additions and changes in the sessions reflecting logistics and learning experience in teaching the course for the first time. The author taught the course as a design experience with the emphasis on applying energy conservation and passive design techniques to real situations. Only a few sessions addressed fundamentals with the remaining sessions involving tours, outside speakers, and discussions of individual and group reviews and reports. The main principles stressed were those necessary to conduct a total energy balance. Emphasis was placed on conduction, convection and radiation, solar insolation, heat pump fundamentals and integration of these concepts. Energy consumption for the quarter length design project was completed using the Brick Institute of America (1750 Old Meadow Road, McLean, Va 22102) worksheets based on accepted ASHRAE procedures. Passive contributions were based on the PSDH II (passive solar design handbook) and quantitative sections of the Mazria text. The group assignments (2 to 3 man groups) involved 1) an estimated performance of a home in Reston with a recently added "Sunspace" (toured in session 3), and 2) an energy evaluation of architecture, engineering and heating system of the Terraset Elementary School. Terraset School was toured in session 6 after extensive results were provided to the students for analysis during session 5. The author has studied and previously published several articles on the performance of the school.

The major individual assignment was the quarter project which centered on 1) completing an evaluation of energy utilization of the students home adhering to ASHRAE techniques. A comparison to actual energy utilization was made when possible. Eight of the nine students selected their personal residence, the ninth a private school gymnasium. Part 2 required the student to propose and evaluate various energy saving and passive gain improvements to the base case. The evaluation required a final design, and an estimate of the total capital investment and payout in years. I required students to complete month by month energy balances using degree day or average temperature information and actual or average insolation data for the Washington, D.C. area. I emphasized these energy balances rather than following PSDH II procedures to determine a typical Building Load Coefficient (BLC), calculate a Load Collector Ratio (LCR), and then estimate a Solar Saving Fraction (SSF) from a chart.

The students were also required to give a presentation on a subject selected by them. Topics included various aspects of heat pumps (2 presentations), thermal shutters, window losses, double envelope house, concepts of solar collectors. I had hoped for a wider selection of original topics in the passive area but did not get it. Next time I'll limit the appropriate subjects to passive concepts and design.

The assignments for those with an engineering problem solving background were not highly technical or complex. However, I believe all the students were being exposed for the first time to ASHRAE Fundamentals and energy calculations, and passive design calculations. As in any new field, it takes time to acclimate to new terms, definitions and dimensions. The students reacted well to the group and individual projects, and classes were very interactive between students and the instructor. I limited enrollment in this graduate course because of logistics in arranging home tours, and to encourage strong classroom participation.

Course evaluations completed by the students were generally flattering and enlightening. I frankly was concerned about maintaining balance between emphazing passive solar and other energy fundamentals, versus group and individual case studies, versus tours and presentations by visiting architects. I chose to emphasize design and evaluation and expose students to numerous energy saving and passive facilities. The students completed computations essentially on their own using the texts and references provided. This arrangement succeeded because the Brick Institute "Energy Conservation" material was technically sound and easily understood although a copy of ASHRAE Fundamentals 1977 is a must. The Brick Institute material includes a worked out example and provides blank worksheets which can be xeroxed and filled out by the students. Similarly the Passive Solar Design Handbook II has worked out examples making application simple - too simple. The ability to conduct a month by month energy balance and appreciate assumption made in carrying out these calculations are needed if a true understanding of passive contribution, particularly through the cold months, is to be appreciated.

I chose not to dwell on hand-held or other larger energy evaluation computer packages. The understanding and initial design experience must come first and assumptions in using these packages must be understood.

Reflections
When I teach this course again I'll use the Brick Institute notes plus ASHRAE Fundamentals 1977 (a must) for energy balances; PSDH II and recent publications from AS of ISES for passive, particularly greenhouse design, selected sections of Mazria, particularly Suncharts which can be helpful in completing month by month heat balances, and the opening two chapters from Ambrose to explain heat pumps. Apparently Los Alamos Scientific Laboratory is in the process of assembling a design package for sunspaces.

I would emphasize again a quarter length project evaluating a modification to an existing home or building. Another possibility would be to design a modification of a proposed new home for improved energy utilization and evaluate the cost effectiveness and payout. In either case the analysis would be completed with some rigor, including month by month heat balances. At the beginning of the course principles would be highlighted. Then, I would assess several existing passive solar facilities of schools, and flavor them with tours and visiting architects who can provide an original, refreshing viewpoint and dimension to us analytical types.

I was most interested in opening the eyes of traditional engineers to a variety of energy saving techniques in conservation, heat pump utilization, as well as passive design. The engineers responded well. If I fail to excite students to the potential of passive solar energy and *conservation*, then the course has been unsuccessful!

TABLE I

ME 4980 - SPECIAL STUDY
DESIGN OF SOLAR SYSTEMS

Course Syllabus: Spring Quarter 1981, Wednesday 7-10 pm

A design and problem solving experience involving presentations by architects, visits and/or analysis of several residences, including your own, a school and an industrial building. We will be visiting and analyzing several appropriate buildings on Wednesday evenings and may have to schedule tours on one Saturday morning.

STUDENT BACKGROUND:
1. Engineering or technical degree, or
2. Some knowledge of thermodynamics, that is, understanding of meaning of enthalpy and heat transfer ("R" calculations). Prior approval needed.

Specific Objectives:
1. To calculate and estimate T.E.B. (Total Energy Balance) for the heating and cooling of your home, Terraset School, and existing home with high passive contribution.
2. To consider as a component of the Total Energy Balance contributions from direct and passive solar and storage, solar collectors, heat pumps, metabolic inputs and appliances. To consider gains and losses from infiltrations and conduction, convection, and radiation through windows, walls, roof, ground and earth berming.

3. To present a book or subject review on a solar architecture or solar engineering book or experience. Use of hand-outs and/or transparencies expected.
4. To incorporate heat pump, and passive or active design concepts into modification of an existing home or building, or preliminary design of a (your) new home or commercial building. This is a final quarter project.

Textbooks:

E. Mazria, *The Passive Solar Energy Book*, Rodale Press, Emmaus, Pennsylvania, 1979 edition. (Paperback)

Total Environment Action, Inc., *Passive Solar Design Handbook: Volume I Passive Solar Design Concepts*, U.S.D.O.E., DOE/CS-0127/1, US-59, 1980.

Los Alamos Scientific Laboratory (J. Douglas Balcomb et al), *Passive Solar Design Handbook: Volume II Passive Solar Design Analysis*, U.S.D.O.E., DOE/CS-0127/2, UC-59, 1980.

R. D. McFarland and R. W. Jones, *Performance Estimates for Attached Sunspace Passive Solar Heated Buildings (With Tables)*, published in AS of ISES meeting proceedings during 1980. Available through L.A.S.L.

R. W. Jones and R. D. McFarland, *Attached Sunspace Heating Performance Estimates*, published in AS of ISES meeting proceedings during 1980. Available through L.A.S.L.

Brick Institute of America (1750 Old Meadow Road, McLean, Va. 22102), *Technical Notes On Brick Construction*, Vol. 4C, 4D, 4E (ASHRAE based energy use estimates), 43A, 43B (Brick Passive Solar Systems).

Selected DOE publications and xeroxed reference materials.

References:

E. R. Ambrose, *Heat Pumps and Electric Heating*, John Wiley Publishers, New York, 1966.

American Society of Heating, Refrigerating and Air Conditioning Engineers. *ASHRAE Handbook, 1977 FUNDAMENTALS*.

J. S. Doolittle, *Energy - A Crisis - A Dilemma - Or Just Another Problem?*, Matrix Publishers, Champaign, Illinois, 1977.

J. F. Kreider and F. Kreith, *Solar Heating and Cooling Engineering, Practical Design and Economics*, Hemisphere Publishing Corporation, Washington, D.C., 1977.

R. G. Stein, *Architecture and Energy*, Anchor Press/Doubleday, Garden City, New York, 1977.

Subject Topic Areas:

Low-cal house
Arkansas hosue
Double envelop house
MIT houses
Passive design computer programs
Window designs

Shutters, shades
Berming
Infiltration losses
Heat pump utilization
Phase change energy storage
Book review

25.2

TOWARD A SUSTAINABLE FUTURE

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International Institute for Energy and Architecture
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Abstract
Leading design researchers and practitioners founded the International Institute for Energy and Architecture (IIEA) to meet headon the challenge of a sustainable future. A vehicle for collaboration and exchange, IIEA seeks to improve the quality of habitat for the world's peoples through increased understanding and development of energy-conserving, climate-adaptive architecture and urban design. IIEA research, education, and technical assistance programs, backed by a committed global network, emphasize reliance on natural energy forms and indigenous methods and materials. As a clearinghouse, IIEA will both initiate and facilitate the international transfer of timely research and design solutions. Institute support functions will offer a keen perspective on the status and potential of climate-adaptive planning and architecture.

Purpose:
The purpose of this paper is to introduce the International Institute for Energy and Architecture and describe its organization, methodology, and program planning and implementation procedures. An effort will be made to clarify how IIEA programs and activities will be matched with various end user needs.

Goals:
IIEA has been established to meet two primary goals:

- to improve the quality of building and habitat throughout the world by encouraging maximum use of local and natural energy sources;
- to promote research and exchange of information on energy-conserving, climate-adaptive architecture and urban design.

Organization:
The International Institute for Energy and Architecture was incorporated as a tax exempt, not-for-profit Institute in September 1980 under the laws of the State of Illinois, USA. The IIEA is divided into 13 geocultural and geoclimatic regions of the world.

01. Middle East
02. Upper North America
03. Indian Subcontinent
04. Industrialized Far East
05. Latin America
06. Pacific Commonwealth Nations
07. Sino-Monogolian Region
08. Socialist Bloc
09. Southeast Asia
10. Subsaharan Africa
11. Western Europe-Mediterranean
12. Western Europe-Northern
13. United States

Within each region a network of energy and design experts has been identified, comprosing the basis of IIEA. International activities, monitored regionally by IIEA Directors, along with specific needs and communications are networked through IIEA offices in the United States. IIEA Board of Directors and Advisory Councils represent recognized experts in building climatology and passive solar architecture throughout the world.

Methodology: Programs/Activities
Serving as a clearing house, the Institute is establishing and conducting programs in research, cooperative education, training and technical assistance. It has organized exhibitions, design competitions and publications. Designed to foster and support vital exchange of data and research, these programs provide new tools and new formats for education in technology, methods and systems of sustainable design.

The Summer Institute for Sustainable Design
While climate and energy have recently become important concerns for a responsive architecture, they have broader implications influencing urban design and patterns of growth. Within these concerns lies a new design challenge: to develop an architecture which acknowledges climate, resources and energy along with the urban context; incorporating social factors and commercial needs, along with new technologies.

Sustainable Design is a multidisciplinary process which seeks to integrate basic systems - transit, power, food, water, waste and shelter -into a more coherent and environmental sound urban form. The annual Summer Institute program is intended to develop and enrich the emerging field of sustainable design by drawing together experts from various disciplines to work with other professionals and advanced students around the world. The Summer Institute will offer course work covering the various fields: climate-responsive architecture, biological systems, social factors, urban planning, energy analysis and local economics. Each Summer Institute program will address a case study studio design problem. Projects, integrating a full range of design issues, will involve the master planning and urban design for growth for a given region. The intent beyond the educational experience, is to produce a workable paradigm of integrated systems and urban design for publication and use by the local planning authorities and regional policymakers.

Participant Catagories:

- *Architects, Designers and Practitioners* will encounter new insights into energy efficient socially responsive building and urban forms. Involvement in the studio will allow this group to shape a unified design method based on a holistic approach.
- *Advanced Degree Candidates* are elegible to participate with full accreditation in addition to scholorship opportunities.
- *Urban Planners* will be challenged with integrating urban systems such a transportation, power generation, waste utilization, food projection, water resources, and housing into an ecologically design methods and construction details, climate and solar data, calculation methods. The primary user of this resource will be scientists, researchers and designers in building climatology and passive solar architecture who desire an efficient system for technical information exchange.

Technical Workshops

Intensive Workshops will emphasize immediate needs and skills development. The first of a series of programs will center on the design and construction of energy-efficient large buildings. Data to be presented will include calculation procedures, thermal modelling, daylighting, design methods, cost analysis, energy use characterization, thermal zones, mechanical systems, preventive maintenance, construction details and post occupancy evaluation. Other planned workshop topics include earth-integrated large buildings and energy economics and energy financing.

Technical Assistance/Technology Transfer

IIEA technical assistance and training program activities will encourage greater use of local materials, natural energy forms and indigenous methods in combination with new technology. International teams wil be assembled to assist countries or economic development agencies with planning, assessment, or specific project-related research and design activities. IIEA will make technology transfer available in an efficient and economical manner for regions of the world where importation of responsive strategy for master planning. *Corporations and Multinational Firms* are encouraged to think about sustainability in the course of their business development activities which directly influence community development and the environment.

Exhibitions

Exhibitions organized by IIEA will graphically display built examples and research results to the world's practitioners, students and public. An example is "Solar 4: Architecture and Energy", a "first of its kind" exhibit of passive solar architecture. This bilingual exhibit, representing the work of four well known solar architectural firms, is currently traveling in West Germany. Solicitations are underway to develop fullscale multilingual worldwide exhibitions of passive solar heating and cooling applications and earth-integrated buildings.

Database

IIEA is assembling a Database to assist in the exchange and dissemination of information on energy-conserving, climate-adaptive architecture and urban design. Currently 2500 entires have been compiled, representing organizations, universities, institutes, practitioners, component manufacturers, researchers and promoters: unique because all are specializing in the passive solar energy field. Additional information for the database includes case studies, technology is constrained by lack of available funding. Such efforts will be implemented through the support of IIEA advisory councils in each geographical area.

Collaborative Arrangements

IIEA will help facilitate multilateral energy-related projects and act as a networking entity among international energy organizations. Definition of research and development needs and assessment of the "state of the art" of the worldwide energy situation are examples of collaborative programs.

Publications

Another element of IIEA's information dissemination role is the issuance of a variety of publications concerning climate-adaptive, energy-conserving architecture and urban design directed to practitioners, researchers and policymakers throughout the world. Publications completed or under design include a newsletter, journal, glossary of passive solar energy terms, an international survey of passive solar architecture and a variety of regional monographs.

Design Competitions

Historically design competitions have served as an educational tool for students and professionals. The process brings practitioners quickly up to date in the latest technology of any emerging design field. Results of competitions are a proven method of communication to significant portions of the academic and public sectors. IIEA fully supports the concept of competitions. Through the resources available in its Advisory Councils, IIEA has the complete expertise necessary to successfully formulate, conduct and jury design competions.

Toward A Sustainable Future

Changes in global perspective on habitat and energy have given rise to new patterns within the international design community. This emerging perspective focuses on an approach that carries the promise and potential to transform the vision of a sustainable future into a reality. Throughout the world, networks of expertise and shared philosophy are evolving, unifying the move toward an improved quality of life and creating local solutions from international experience. From within these networks, the International Institute for Energy and Architecture has grown. Only through collaboration and shared goals can the world together move to an era of sustainability. The IIEA facilitates collaborative action in ways that clearly show the potential benefits of architecture and urban design responsive to environment and local needs.

25.3

ENERGY AWARENESS IN FLORIDA

Thompson and S.A. Lofaro
Daytona Beach Common College
Daytona Beach, FL

Abstract
Daytona Beach Community College, under a Florida Governor's Energy Office grant, sought to identify educational energy-awareness and conservation needs throughout the State of Florida. Further goals were to form an energy-awareness network for dissemination of energy data while planning to produce multi-media modules on energy-awareness and conservation.

In December of 1979, Daytona Beach Community College conducted a survey of the community colleges and vocational/technical schools within the state. This survey determined both attitudes on energy, such as belief or disbelief in an energy crisis, as well as energy concepts/courses already in place. The survey also ascertained the interest level in energy and its conservation among the 56 institutions comprising community colleges and vocational/technical centers. Fifty-five institutions actively participated in the survey; 1,880 survey instruments from full-time faculty members were returned to DBCC, out of the 2,630 distributed (each department received a maximum of five (5) instruments). This reflected a 71% return rate. Following tabulation of the survey data, three (3) statewide conferences were held in order to both form a network of representative community college and vocational/technical personnel and to disseminate the survey data. These conferences became vehicles for planning future procedures as regards energy education.

The survey results showed (1) A belief that the energy crisis is real, long-term and solvable. (2) A belief that energy awareness and conservation modules can be incorporated, in the main, into existing courses and curricula. (3) A view that the community colleges and vocational/technical institutions are and should be primary vehicles for energy education. (4) A belief that audio-visual presentations are the "treatment of choice" for presenting energy education, and finally, (5) the recommendation that a dedicated corps of people be formed from those who either wish access to pre-made audio-visual energy presentations or who wish to collaborate in the preparation of audio-visual materials for their particular discipline areas.

The results of the survey as disseminated and discussed in the conferences were incorporated into plans meeting the identified needs. These are intially to produce four (4) complete media modules on energy to aid institutions with energy-awareness in their curricula. These modules will focus on introducing energy awareness and conservation into the broad curricula of Business, Building Trades, Humanities, and Home Economics which are the initial target areas of request.

These modules will be introduced to community colleges and vocational/technical institutions in two (2) state-wide workshops. The energy modules will then be made available to all interested institutions thru the Florida Governor's Energy Office.

SESSION 26: OUTREACH AND TECHNOLOGY TRANSFER PROGRAMS

26.1

USED CRANKCASE OIL DISPOSAL PRACTICES: IMPLICATIONS TO RECYCLING PROGRAMS

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Abstract
A used oil survey conducted in two states, Rhode Island and South Carolina, revealed that used oil recycling programs are feasible in areas of widely divergent demographic characteristics. The popularity of changing one's own lubricating oil varies regionally as do the methods used to dispose of the used oil. Residents in both states had positive attitudes toward recycling. The survey results indicated that the two key factors toward success of a used oil recycling program are convenience of the collection centers and education of the residents about the program's existence. In practice, there are funding and logistical constraints to effective educational campaigns. Energy educators can help these programs by including this topic in recycling sections of their curricula.

Introduction
The recovery and recycling of used lubricating oils has been the subject of recent legislation, both on national and state levels. It is clear that Federal policy, as exemplified in the Energy Policy and Conservation Act of 1975, the Resource Conservation and Recovery Act of 1976 and the Used Oil Recycling Act of 1980, encourages recycling of used oils. The advantages of this policy are both economic and environmental. Not only is used lubricating oil a useful resource which can be re-refined (at lower cost than to refine new oil for lubrication) but also it can be used as a fuel after only some minor cleaning procedures. The environment benefits from used oil recycling in that every gallon which is re-refined or cleaned does not contaminate the soil, groundwater, rivers and the oceans.

As a part of a project to determine the sources of oil pollution to Rhode Island's major estuary, Narragansett Bay, it was necessary to determine how much oil was getting into the bay from do-it-yourselfer oil changers dumping their used automotive oil down sewers. At the same time, the legislature of the State of Rhode Island was considering legislation to encourage recovery of this used oil. The survey was therefore designed to find out (1) how many do-it-yourselfer oil changes there were in the state and thus determine the economic feasibility of starting such a program and (2) what methods people used currently to dispose of their used oil as a first step to address potential environmental impacts.

Rhode Island and South Carolina are among 47 states which are currently members of the National Association of Oil Recovery Coordinators. The Rhode Island survey was conducted in the fall of 1979, and the questionnaire was made available to these State coordinators in April 1980. Since South Carolina was also in the process of collecting data to serve as a basis for legislation, this survey questionnaire was expanded and was used again in South Carolina to gather their local data. Therefore, this paper is the result of two used oil surveys conducted in two different states using a questionnaire that was virtually indentical with respect to used oil items. Because the Rhode Island questionnaire[1] was directed soley toward residents of the City of Providence, a highly urbanized area, and the South Carolina survey[2] also included suburban and rural population segments, the comparison of these data provided useful demographic differences which are of great utility in the design of used oil recovery programs tailored to the specific region of interest.

Methodology
The Rhode Island questionnaire and the segments of the South Carolina questionnaire dealing with used oil are given in Figures 1 and 2. The two versions are very similar. The original questionnaire from Rhode island was pretested twice, once by personal interviews to determine its readability and attractiveness and once by mailing to determine the anticipated response rate.

A comparison of the survey techniques used in the two states is given in Table 1. In both surveys, the names of the individuals sent questionnaires were selected from the respective telephone books using systematic random sampling. The response rates after the first mailing, 33.5% and 34.4% were similar. In Rhode Island a reminder letter with a duplicate questionnaire was sent after one month to those individuals not responding the first time. This accounts for the higher total response rate in Providence. Because the original number of people sent questionnaires in South Carolina was larger, the individual responses, 417 vs. 492, were very similar in the two surveys.

In order to provide additional demographic data, the South Carolina responses were divided into two categories, rural and urban. The rural areas were defined as towns less than 25,000 in population; urban areas were towns greater than 25,000 with no town in South Carolina exceeding a population of 97,000, and maximum population density of 900 people/square mile. The Rhode Island study questioned exclusively residents of the city of providence, a city of 179,000 with a population density of 9900 people/square mile. The Rhode Island area considered can be classified as highly urban.

Results and Discussion
A. Car Ownership. The distribution of cars in each household in the survey area is given in Table 2. The data indicates that there are fewer cars/household in Providence. This probably reflects the availability and popularity of mass transit in Northeastern cities. Even though the number of cars per household in Providence is smaller, the increased population density there makes the numbers of potential lubricating oil customers per unit area greater than the urban areas of South Carolina.

B. Frequency of Oil Changes. The frequency at which the car-owning population changed the oil in their cars is given in Table 3. The frequency of oil changes was similar in urban and rural areas in South Carolina and Rhode Island.

C. Do-it-yourself Oil Changers. The percentages of do-it-yourself oil changers in each study area are given in Table 4. Again, there is a difference which can be attributed to demographic considerations. As the population density in the study areas increased, the percentages of do-it-yourselfers decreased. Coments made by some of the Rhode Island respondents indicated that more people would change their own oil if they had an easy way to dispose of the used oil.

D. Point of Purchase. The types of places at which do-it-yourselfers bought their oil are given in Table 5. The places given are similar in both study areas although discount stores seem to be more popular in urbanized areas. This is probably due to the increased proximity and availability of these outlets in cities. No Providence residents responded that they bought their oil at grocery stores even though grocery stores do carry lubricating oil. It is likely that the grocery store prices in R.I. are not competitive with other outlets. In addition to the three predominant outlets, outlets in the "other" category include wholesale distributors, oil companies, bulk oil plants, military base exchanges, drug stores and large department stores. When advertising the existence of a local or state recycling program, at the very least, posters and collection center information should be posted at all the local discount houses and auto supply stores and expanded to other outlets as local conditions indicate.

E. Methods of Disposal. The disposal methods utilized by the survey respondents are given in Table 6. At the time of this survey, the only existing used oil disposal method leading in some degree to its recovery was taking the used oil to a service station. The service station owner could either sell his used oil to a waste oil collector or burn it as a fuel to heat his station. In both states the practice of giving used oil to a service station is unpopular. This may be the result of two considerations. It is inconvenient to take the oil anywhere (as demonstrated by later responses) and service station owners in the past have not been willing to accept the oil from do-it-yourselfers, reasoning that this could cut into their own lubricating services. About six months before this survey was conducted in Rhode Island, the environmental groups Ecology Action for Rhode Island and the Rhode Island Audubon Society convinced the Ocean State Service Station Owners Association to start accepting used oil from do-it-yourselfer oil changers. This agreement, however, was not widely publicized and there was little impact of this program on the general public. The State of Rhode island has only very recently started its own recovery program but it is centered around service stations who volunteer to be collection centers for the used oil from do-it-yourselfers. To date, 113 service stations have volunteered. Because the publicity campaign has just begun, it is too early to determine whether the number of people taking their oil to service stations will increase.

In Providence, the most popular disposal technique was simply to throw the oil into their garbage cans. By comparing the South Carolina and Rhode Island results, it is apparent that garbage can disposal's popularity also increases with increasing population density. In South Carolina, however, the most popular method is to pour the oil out in their backyard. This technique is not as popular in Providence since the land devoted to yards is quite limited.

The percentages of people pouring their oil on the road are low at both surey areas. This technique seems to be slightly more popular in urban areas. The percentage of do-it-yourself oil changers who dump their used oil down sewers or catch basins is clearly higher in the highly urbanized city. The catch basins in the city of Providence are, unfortunately for receiving water bodies, a very convenient way to dispose of the oil, especially if the cars are parked on the streets when the oil is changed.

The practice of taking the used oil to the local town dump appears to be more popular in rural areas than n urban regions. This response may also be inflated over actual conditions since this choice may be perceived by the respondents as being the most environmentally acceptable response. For example, 2.8% of the Providence respondents said they took their oil to the town dump. This result is hard to interpret because Providence does not have an active town dump. These respondents could actually be using some other disposal method or could be dumping it sureptitiously at unofficial or inactive dumps.

Waste Disposal in South Carolina

PLEASE INDICTE BY A CHECK-MARK ( ) OR BY FILLING IN THE BLANK YOUR RESPONSE TO EACH ONE OF THE FOLLOWING QUESTIONS.

1. Do you take your used aluminum beverage cans and other scraps of aluminum to a recycling center?

   ( ) Yes
   ( ) No, there is no recycling center for aluminum in my area.
   ( ) No, it is not convenient for me to take it to the center.
   ( ) No, I don't know if we have a local recycling center.

2. Do you take your broken glass and old glass bottles and jars to a recycling center?

   ( ) Yes
   ( ) No, there is no recycling center for glass in my area.
   ( ) No, it is not convenient for me to take it to the center.
   ( ) No, I don't know if we have a local recycling center.

3. Do you take your old newspapers and other used paper to a recycling center.

   ( ) Yes
   ( ) No, there is no recycling center for paper in my area.
   ( ) No, it is not convenient for me to take it to the center.
   ( ) No, I don't know if we have a local recycling center.

4. Is (Are) your recycling center(s) run by a private company or as a community or school service?

Aluminum	Glass	Paper
( ) Private company	( ) Private company	( ) Private company
( ) Community service	( ) Community service	( ) Community service
( ) School service	( ) School service	( ) School service
( ) Other ________	( ) Other ________	( ) Other ________
( ) Don't know	( ) Don't know	( ) Don't know
( ) No center	( ) No center	( ) No center

5. How many cars do you and your family (living with you) own? ________

6. How often do you change the lubricating oil in your car(s)?

( ) Once every 1-3 months
( ) Once every 4-7 months
Once every 8-12 months
( ) Other (specify) ________

7. Do you usually change the lubricating oil in your car(s) yourself, or do you have the oil changed for you?

( ) We change it ourselves.
( ) A service station changes the oil.
( ) A discount or auto service center changes it.

II. PLEASE COMPLETE THE FOLLOWING SECTION **IF YOU OR YOUR SPOUSE CHANGE YOUR OWN OIL.** OTHERWISE SKIP TO SECTION III.

1. Where do you usually purchase your oil?

( ) Convenience store
( ) Grocery store
( ) Discount store
( ) Auto supply store
( ) service station
( ) Other (specify) ________

2. What do you do with the used lubricting oil form your car(s)?

( ) We give it to a service station.
( ) We put it in our garbage can.
( ) We store it at our home.
( ) We pour it out or bury it on our property or a neighbor's property.
( ) We pour it on the road.
( ) We pour it down the storm drain or sewer.
( ) We take it to the town dump.
( ) Other (please specify) ________

3. If you store your waste oil, what do you keep it in?

( ) A storage tank
( ) Metal drums
( ) Gallon cans
( ) Metal or plastic buckets
( ) Other (specify) ________
( ) We don't store the oil

4. Would you be willing to package your used lubricating oil to a recycling barrel if such a program were available in South Carolina?

( ) Yes
( ) Yes, if a recycling barrel were close to our home.
( ) Yes, if a recycling barrel were close to our favorite shopping center.
( ) Yes, if a recycling barrel were located at our town dump.
( ) Yes, if it were picked up by my public or private garbage collector.
( ) No, it would no be convenient for us to participate.

III. 1. I am: ( ) Male ( ) Female

2. I am: ( ) White ( ) Black ( ) Other (specify) ________

3. Which of the following income categories comes **closest** to your family's total yearly income in 1979?

( ) Under $10,000
( ) $10,000 to $14,999
( ) $15,000 to $19,999
( ) $20,000 to $24,999
( ) $25,000 to $34,999
( ) Over $35,000

4. Finally, in what year were you born? ________

Thank you for your time. Please check to see that you have answered all questions that apply to you. Then mail this questionnaire using the postage-paid reply envelope enclosed.

Table 1.

METHODS USED

	S. Carolina	Rhode Island
Contractor	Metromark Market Res.	University of R.I.
Method of selection	random from telephone book	random from telephone book
No. of questionnaires mailed	1439	1000
% returned by post office	13.4%	7.7%
% completed questionnaire first mailing	33.5%	34.4%
% completed questionnaire total	33.5%	53.5%
Total responses received	417	492
Sampling error	5%	5%
Type of population surveyed	rural & urban	highly urban

Table 2.

CAR OWNERSHIP

	S. Carolina		R.I.
	rural	urban	highly urban
No car	6.0%	3.5%	13.3%
One car households	35.3%	33.7%	46.6%
Two car households	39.4%	43.7%	30.7%
More than two cars	18.8%	17.1%	9.4%

Table 3.

FREQUENCY OF OIL CHANGES

	S. Carolina		R.I.
	rural	urban	highly urban
Once every 1-3 mo	13.7	13.3	21.1
Once every 4-7 mo	58.8	53.2	53.1
Once every 8-12 mo	17.6	20.2	20.3
Other	7.8	11.7	5.5

Table 4.

DO-IT-YOURSELFERS OIL CHANGERS

	S. Carolina		R.I.
	rural	urban	highly urban
Do-it-yourselfers	*48.5*	*39.9*	*33.5*
Service stations	*51.5*	*59.5*	*66.5*

Table 5.

WHERE IS OIL PURCHASED

	S. Carolina		*R.I.*
	rural	*urban*	*highly urban*
Discount store	48.0	51.9	59.5
Auto supply	23.0	26.0	11.8
Grocery store	9.0	13.0	0
Other	20.0	9.1	28.7
wholesale distributors			
oil companies			
bulk oil plants			
military base exchanges			
drug stores			

Table 6.

METHODS OF DISPOSAL

	S. Carolina		*R.I.*
	rural	urban	highly urban
Give it to service station	3.0	10.4	6.9
Put in garbage	14.0	23.4	40.7
Store at home	5.0	6.5	4.1
Pour it out or bury it	38.0	39.0	29.7
Pour it down sewer	1.0	2.6	7.6
Take to dump	9.0	3.9	2.8
Other	24.0	14.3	3.5

Table 7.

"OTHER" DISPOSAL METHODS

	No. of responses	
	S. Carolina	R.I.
Pest control		
kill weeds	5	1
on cows for ticks & flies	1	0
under house for termites	1	0
kill ants	1	0
Preservative		
grass around fences	3	0
wood preservative	4	2
fence posts	1	0
Oil for machinery		
oil farm machinery	4	0
chainsaws & lawn mowers	3	0
tools	3	0
Oil for burning	6	1
Dust control	1	1
Others		
use at work	0	2
pour around pecan trees	1	0
pour into dry well	0	1

Table 8.

PARTICIPATION WILLINGNESS

	S. Carolina		R.I.
	rural	urban	highly urban
Yes	73.0	83.1	93.8
No	27.0	16.9	4.1

Table 9.

PARTICIPATION FORM PREFERRED

	S. Carolina		R.I.
	rural	*urban*	*highly urban*
Close to home	78.0	66. 7	71.1
Close to shopping center	6.0	9.5	24.6
At dump	0.0	2.3	4.3
If picked up	16.0	21. 4	--

26.2

TECH TRANSFER IN GEORGIA TECH'S ENERGY PROGRAMS

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Abstract
Georgia Tech's Engineering Experiment Station has been intrumental in making residential and industrial sectors aware of energy conservation and alternate energies. A variety of technology transfer mechanisms, each geared to a specific audience with preconceived notions, have effected significant reductions in energy usage. Briefing reports, applications manuals, seminars and workshops, audiovisual programs, direct personal contact, and promotional materials are all tools that Georgia Tech has used. This paper will present specific examples of how these tools have been used effectively.

Introduction
The Technology Applications Laboratory's Technology Transfer Branch is part of the Engineering Experiment Station of the Georgia Institute of Technology. The Engineering Experiment Station is an applied research organization conducting investigations in engineering, science, computer technology, and economic development for a variety of sponsors that include federal, state, and local governmental agencies, industrial firms, and foreign countries. As chartered by the Georgia Legislature, its purpose is to serve the community, state, and nation by performing technical research, encouraging development of natural resources of Georgia;,advancing science, technology, and education, aiding industrial and economic development, and participating in national and international programs of science, technology, and preparedness.

The Engineering Experiment Station currently has a staff of nearly 600 full-time professionals, 1200 full-time personnel, and additional support from 400 faculty, students, and consultants that prticipate on a part-time basis. This past year in excess of 400 contractors and grants were executed, ranging from small efforts to multimillion-dollar programs.

The Technology Applications Laboratory (TAL) is one of eight major administrative units of the Engineering Experiment Station. Primary emphasis within the Laboratory is placed on developing engineering technology that is economically practical and is effective in communicating technical information to industrial audiences and to individuals. Sources of funding include the U.S. Department of Energy, the Georgia Office of Energy Resources, the U.S. Department of Energy, the Georgia Office of Energy Resources, and the U.S. Department of Agriculture as well as the U.S. Agency for International Development, the World Bank, the Organization of American States, the Korea Credit Guarantee Fund, and numerous others.

Methods of analysis
Because audiences vary widely, an important first step is to determine the appropriate technology transfer mechanism to disseminate technical results to potential users. It is necessary to:

- Identify target audiences through contacts with trade associations, technical societies, government agencies, and community organizations
- Determine potential users' needs
- Relate technical data to practical applications
- Assess the information required for transfer

A market study can often define the problems and optimum solutions to implementing proposed technologies. This includes evaluating current technologies to be replaced or upgraded, determining potential or perceived barriers to application, and examining the causes for those barriers.

The results of the study will determine the specific audience to be addressed which, in turn, will determine the most effective transfer mechnanism. For example, a business executive may not have time to sit through an 8-hour workshop; but he could be induced by means of a high quality, concise briefing report to send his technical manager. Small business owners, aware of the technologies available but without the technical or monetary resources for implementation, would respond favorably to a step-by-step applications manual. Homeowners are delighted to come to exhibits of hardware they can use and find how-to manuals very handy, but they do not often attend full-day workshops with a sizable registration fee. Policy makers are busy people often bombarded by lobbyists from all sides; briefing reports or short concise presentations with a significant message are better methods of communication than lengthy seminars or reference manuals.

Georgia Tech's Energy Programs
The Technology Applications Laboratory has participated in a number of energy programs over the years. Presented below are four typical examples.

Industrial Energy Extension Service
The Industrial Energy Extension Service, commonly known throughout the State of Georgia as IEES, is in its fourth year of funding through the Georgia Office of Energy Resources. IEES is designed to stimulate more efficient use of energy resources by the industrial community through individual technical assistance and technology transfer. The program is voluntary and offered at no cost to Georgia industries.
Initially, the IEES was promoted by press releases, brochure mailings, phone solicitation, and other forms of advertisement. Within a year, however, enough momentum was gained in the individual technical assistance area to make an active promotional campaign for this type of work unnecessary. In fact, since the initial start-up period, the program has maintained a backlog of firms desiring energy audits or

technical assistance. Promotion of technology transfer efforts, of course, remains an ongoing part of the IEES program. The IEES program results to date: over 74 billion Btu's saved or $217.5 million that can be utilized by industry for purposes other than buying costly energy.

The technology transfer efforts of IEES have been widely and favorably received. Applications manuals have been prepared to accompany practically all of the 50 workshops. A bi-monthly newsletter, the *Conserver*, is now mailed to more than 6000 business and industry representatives. This publication continues to serve as an excellent vehicle not only to transfer energy saving ideas but also to keep industry aware of program efforts. Of the 32 Energy Tips developed to date, more than half have been published in *Chemical Engineering* magazine, with two of them receiving second and third prizes as best short articles published in 1980. Briefing reports concentrate on specific areas with particularly high energy conservation potential and have been distributed to industry both in and out-of-state.

Wood Heaters of Homeowners

Several years ago the Technology Applications Laboratory embarked upon a program to revitalize interest among homeowners in using wood for space heat. Georgia imports 97% of its energy; yet a valuable resource that is abundant in the State was going to waste. Under State of Georgia funding through the Georgia Forestry Commission, Georgia Tech engineers designed a mobile exhibit that logged 8000 miles of travel and attracted over 25,000 visitors in its first year of operation. Two 40-foot trailers were equipped with wood heaters and wood furnaces typical of those available on the market. Each unit was accompanied by descriptive material on design features and cost. In addition, educational pamphlets on how to buy, install, operate, and maintain wood heaters were made available.

A spin-off of this successful program was funded by the Tennessee Valley Authority (TVA). Georgia Tech produced three two-day workshops for TVA's Wood Heater Project. TVA loans $800 interest-free for the purchase and installation of wood heaters; but before the loan is approved, the stove installation must pass a thorough inspection. Our workshops trained 70 wood energy advisors to inspect the installations as well as to provide safety information to homeowners.

"Safe and Warm Wood Heat" was compiled as a training manual for the inspectors; however, it proved to be very popular with homeowners, retailers, building code officials, and fire marshals also. Nearly 12,000 copies have been distributed and an expanded edition will be available for distribution this fall.

A State Demonstration in Wood Energy

The wood energy program is concluding its second year of operation in Georgia. Funded by the Department of Energy through the Georgia Office of Energy Resources, Georgia Tech offers technical assistance and information to nonforest industries on the use of wood as an industrial fuel. The entire spectrum of technology transfer mechanisms has been used to generate interest in this abundant natural resource of the Southeast. Of the 40 companies for which feasibility studies were conduced, 75% are actively interested because of the fast paybacks demonstrated. If only half of these plants convert to wood, 250,000 gallons of fuel oil and 2.5 billion cubic feet of natural gas will be displaced.

International Technology Transfer

The International Division (ID) is an administrative unit within the Technology Applications Laboraory. It consists of a core of highly trained professionals representing the fields of mechanical engineering, civil engineering, industrial engineering, sanitary engineering, physics, and chemistry. The International Division has conducted research projecters for the past 15 years throughout the world and is currently active in Haiti, Ecuador, Jamaica, the Dominican Republic, the Philippines, Sri Anka, Indonesia, Korea, and Tunisia. International programs include planning, design, construction, and evaluation of energy conservation and alternative energy technologies, information transfer, and technical assistance.

Energy conservation programs range from design and installation of new types of heat exchangers to the technical background for a major energy conservation effort by the Government of Jamaica. Georgia Tech personnel have evaluated conservation measures for foreign countries and have examined and made recommendations on the necessary institutional support to achieve energy objectives.

A program is presently being conducted in Haiti in the area of solar desalination. Several prototypes have been designed and tested, and within the next few months a 30 square meter unit will be fabricated near St. Marc in Haiti. The international staff also worked with a counterpart organization in Kuwait on the development of an absorption air conditioner appropriate to that country.

Several programs in the area of solar-cookers have been conducted. A one-year program was conducted in Mali during which the staff designed, fabricated, and tested several models of solar-cookers. A new type of "spiral" concentrator has been recently developed at Georgia Tech as a result of this research and is now being tested under field conditions in Mali.

The staff of the International Division have presented training courses both at Georgia Tech and overseas since the early 1960's. Professionals from nearly all of the Latin American countries, and from Egypt, Nigeria, Ghana, Morocco, Korea, Indonesia, and the Philippines have received training in subjects such as energy, conservation, technology transfer, information handling, market analysis, and feasibility studies. Each of these programs has been custom designed to meet the specific traning needs of small groups of people.

The International Development Data Center (IDDC) is the information collecting and disseminating unit of the International Divsion. IDDC features a specialized collection of more than 5,000 documents related to alternative energy systems, water and sanitation, small-scale industry, appropriate technology, and developing countries. Computer terminals installed in the Center provide access to more than 150 on-line indexing and abstracting data bases with millions of citations.

Typical services of the IDDC staff include the following:

- Literature searches and specific problem-oriented research in energy and water.
- Compilation of bibliographical materials, special reference quides, and directories.
- Instruction and assistance in establishing information support for energy and water development programs in LDCs.

- Technical assistance to established data centers in counterpart countries and other LDC institutions.
- Compilation and publication of international-oriented newsletters, brochures, and similar publications.

26.3

IMPACTING ENERGY POLICY THROUGH TECHNOLOGY TRANSFER

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Introduction
The Florida Solar Energy Center (FSEC) has established a technology transfer program which offers a unique opportunity to affect state energy policy.
Because of the seriousness of current energy problems and the associated increase in activity in legislatures and government agencies, it is extremely important that accurate, objective, clear and concise information be transferred to policy and decision makers. Faculty and researchers at educational institutions have both the right and responsibility to share their views and expertise with government leaders. This paper discusses the Center's program to broaden the knowledge base prerequisite to making prudent energy policy decisions.

Organization
The Florida Solar Energy Center is a statewide institution staffed by approximately 75 employees from a variety of tecnical and non-technical disciplines. It is part of the State University System of Florida and its activities and responsibilities, broadly stated, include: research and development, systems engineering and analysis, standards development, equipment testing and certification, technology demonstration and applications, institutional analysis, and technology transfer.
The Center has three divisions: Research and Development, Testing and Laboratories, and Engineering and Applications. The responsibility for technology transfer rests in the Engineering and Applications Division and, consequently, there is a very strong association between the technology development and the technology transfer processes.
The professional staff within the division includes engineers, architects, a research attorney, business majors, and education and information specialists.
Technologies which are currently being researched, tested, analyzed and transferred include solar waste rand pool heating, active solar heating and cooling, passive solar and low-energy building design, photovoltaics, wind and ocean thermal energy conversion.

Target Audiences
Target audiences can be categorized under three general headings: (a) the public, (b) educators and (c) the implementation sector. Each of these three groups is important, has differing needs, and may have direct and indirect impacts on energy policy development and decision making.

Despite the fact that energy policy formulation is affected by many inputs from the public, education and implementation sectors, there are relatively few groups which have direct responsibility for energy policy implementation. Within the state of Florida, they are: the governor and the Governor's Energy Office, the legislature, the courts, the Public Service Commission, the Department of Veteran and Community Affairs, the Department of Professional Regulation, the Department of Agriculture and Consumer Services, the Department of Transportation, and local governments.
It should be emphasized that the Florida Solar Energy Center has no policy making authority or responsibility. However, the Center has assumed the responsibility for providing energy policy recommendations to those organizations requiring and/or requesting such information.

Activities and Results
Past, present and imminent activities in which the Florida Solar Energy Center interacts with policy making organizations include: the development of policy action plans, solar commercialization needs assessments and recommendations, legislative briefings on technology status, policy and bill analysis for legislative committees, development of solar standards and the associated administrative procedures, establishment of research and development priorities, feasibility studies for local governments considering energy options, support for state agencies involved with implementing energy legislation and regulations, assisting in the establishment of a solar contractor license classification, and conducting special education and training programs in response to the needs of government. Although all of the above activities are considered important, only those with the greatest impact on policy formulation will be discussed.

Policy Action Plans
In August 1979, the FSEC received a request from the Governor's Energy Office (GEO) for policy recommendations in the area of solar energy. They preferred that our response be phrased in terms of a numerical goal (similar to the Domestic Policy Review) to target the number of solar systems in place by a specified year, given a certain amount of government assistance in goal attainment. Our task was to establish that goal and suggest how to reach it. The ultimate numerical goal established was 500,000 solar installations by 1986, and the recommended program actions to achieve it included the following: establish a task force to resolve the solar licensing/codes issue; restrict the use of non-renewable resources for swimming pool heating; restrict the use of electric resistance water heating; include energy impact assessment in the state planning process; assess the potential of biomass energy resources; develop a comprehensive solar consumer assurance program including installer training and licensing, consistent solar codes, standards implementation, and warranty insurance; establish a preferred utility rate structure for solar users; direct utility R&D funds to renewable energy technologies; impose an energy user's tax to provide solar subsidies; establish a property tax exemption for solar; and intensify solar educational activities for practitioners, educators and the general public.

The Florida Solar Action Plan containing these recommendations and supporting data was forwarded to the Governor's Energy Office. A number of legislators who contacted FSEC with similar requests for policy recommendations aslo received copies of the document. In January 1980, Governor Graham announced energy recommendations to the state legislature at a press conference called specifically for that purpose. Sixteen major items addressing electric energy consumption, transportation, and potential funding sources for the suggested program were revealed. The Governor's comprehensive program incorporated most of the FSEC recommendations.

1980 Legislative Response

Key legislation passed by the 1980 session can be classified into four main categories: 1) utility-related programs, 2) tax incentives, 3) codes and standards, and 4) research and development funding.

The Florida Energy Efficiency and Conservation Act (FEECA) included provisions implementing the Residential Conservation Service (RCS) program; requirements for the develpment of utility conservation and efficiency goals; and a prohibition of utility rates which discriminate against solar users.

The National Energy Consrvation Policy Act of 1978 established the Residential Conservation Service Program. The Florida Energy Efficiency and Conservation Act, passed by the 1980 legislature, went a step beyond the federal legislation by requiring that all Florida electric and gas utilities participate in the program, regardless of volume or regulatory jurisdiction. Because of its high potential impact, FSEC chose to become heavily involved with the renewable portion of the RCS program and subsequently developed computer programs, auditing procedures, a Florida RCS manual, and training programs for utility auditors.

The 1980 Florida Legislatuare authorized an ad valorem tax exemption for renewable and energy-conserving devices. The net effect of the exemption is the assurance that, for a 10-year peroid, property taxes will not increase due to the installation of specified conservation and renewable energy property.

Two important events occurred in the codes and standards area which affect solar applications: legislation adopting a model energy efficiency code for buildings and the legislative requirement for the implementation of mandatory solar water and pool heating standards. The Model code is important for solar applications in that significant credit points are awarded for the installation of solar water heaters as well as for overhangs and designs that promote natural ventilation. FSEC plans to use data from its new passive cooling experimental facility to assist the Department of Veteran and Community Affairs in updating and improving the code.
The mandatory solar system standards were developed and are currently being implemented by FSEC. The 1980 legislature appropriated $4 million for energy research, development and education. Of this total, approximately $1 million is being spent in public education and awareness. The balance, or about $3 million, will be used to fund research and development activities.

Reassessment of the Policy Plan

The approach to development of the first Florida Solar Action Plan (FSAP I) was based on achieving a set goal, in numbers, of solar installations in place. Recommendations were formulated that would surge past socio-economic and political barriers which currently restrict solar commercialization in Florida. All the recommendations were premised on legislative action to achieve the goal. While some recommendations necessarily had higher priority than others, none were divised as pawns to be sacrificed at the bargaining table. Of the eleven points proposd by the Governor's Energy Office, only one, the property tax exemption, survived the legislative process. Rather than representing an indictment of the legislative processes the experience indicated to us that a degree of analysis of the appropriate forum for problem resolution was essential. Bombarding the legislature with recommendations which could be better implemented by other entities in the public and private sectors was no longer advisable.

A Second Policy Action Plan

In August 1980, the Governor's Energy Office once again requested policy recommendations in preparation for the 1981 legislative session. FSAP II reviewed the recommendations and disposition of FSAP I, and restricted 1981 recommendations to three basic areas: energy research and development, education/training/licensing, and incentives.

Once again, the approach to making recommendations was goaloriented; however, the recommendations were quite as comprehensive as those in FSAP I. Given the time constraints of the legislative session (60 days), concentration on the three areas mentioned above rather than an all-inclusive effort was determined to be the only feasible approach. Only those actions which were most appropiately within the province of the legislature were included.

In January 1981, the Governor's Energy Office submitted another request to FSEC. Governor Graham was of the opinion that solar was not progressing as quickly as he would like in the Sunshine State. Rather than limit the request this time to possible legislative initiative, the governor was interested in any and all actions which would accelerate the pace of solar commercialization.
In response to this latest request, FSEC first identified the following problem areas with solar commercialization: high costs; lack of builder, developer and consumer acceptance; lack of maturity and stability of the solar industry; lack of familiarity with solar in building departments; and concerns and posture of utility companies. These problems were followed with a series of recommendations in the areas of utility actions, economic incentives, codes and standards, research and development, and education and training.

For a variety of reasons, possibly including the influence of President Reagan's fiscal and energy policies, there was much less energy activity in the 1981 legislative session. Two important bills passed both houses, however. One authorizes the Florida Public Service Commission to establish guidelines and set rates for public utility purchase of power from cogenerators and small power producers. The other bill authorizes the Department of Veteran and Community Affairs to modify, revise, update and maintain the Model Energy Code. The Center plans to be involved with implementing the second bill.

Current Approaches

Currently the Center is using four approaches in attempting to affect energy policy: the legislative process, voluntary actions by the private sector, administrative actions by the governmental sector, and the efforts of educational institutions. Some of the more important strategies being pursued include: favorable utility rates for solar users; favorable utility connection fees for solar homes; utility encouragement for solar applications in energy auditing, advertising and energy-saver home awards; attractive solar financing; corporate tax credits for builders who install solar systems; an improved model energy code for buildings; local enforcement of the solar standards; restrictions on the use of electric resistance water heating; establishment of a statewide solar contractor license classification; streamlining of the building permitting process so that only one permit is required for a solar installation; increased funding for enegy education and training, especially for solar practitioners.

Conclusions

In a period of decline is fossil fuel supplies and rapid change in energy technology, it is imperative that an efficient two-way flow of information between educators and policy makers be established. There are a number of approaches to impacting energy policy that can and should be pursued. Voluntary actions from the private sector, administrative policies from the governmental sector, and the efforts of educational institutions are often superior to legislation in achieving energy objectives.

Institutions of higher learning involved with energy research, development and education, possess unique multidisciplinary resources that should be utilized to their fullest extent in shaping energy policies that will both make the nation secure and improve the quality of life for its citizens.

There are obstacles to overcome in order to implement such a program, some of which are reoccurring. First, a heavy financial commitment is required for start-up, including salaries, promotion, materials, and travel. The cost can be as high as $30,000 which, within the early life of the program, is expected to be recovered through short course fees. Second, marketing a program of this magnitude requires an ongoing effort of updating mailing lists, promoting through the news media and technical associations, advanced scheduling of the programs, and personal contacts. Time and effort is required to integrate the teaching staff into the program so that overall objectives are reached with a minimum of redundancy or extraneous material.

Undergraduate Energy Courses

Two Nuclear Science and Engineering classes utilize a "point and counterpoint" style to bring different perspectives of energy use into focus. The classes are attended during the academic year by approximately 500 students from about 40 different departments. Non-engineering students make up about half the course enrollment. Recognizing that college graduates from all disciplines will play important roles in shaping the energy future, both sociological and technological viewpoints are addressed.

The "point and counterpoint" format is a scheduled but unrehearsed discussion first focusing on the growth versus no-growth issue. The predictions of the Malthusian Doctrine[2] initiate the discussion. This relationship of an arithmetic food supply and a geometric population growth are contrasted with the discovery of the fixation of nitrogen and the "green revolution". The need for energy resources to fix nitrogen and the compounding consequences of the exponential growth in appetite for energy resources are correlated to the underlying mathematical relationships of energy use as defined by Bartlett[3]. The effect of exponential growth in a limited environment portends the Gaussian shaped energy resource exploitation curves of M. King Hubbert[4].

The concurrent effects of the astonishing accuracy of Hubbert's forecasts, the timing of the reversal in the cost of energy at the margin in the United States, and the impact of the war in the Middle East in October 1973 are related to the current energy crisis. Oil, natural gas, coal, and solar-based resources to demonstrate the universality of risk and benefit associated with all sources of energy.

Due to its controversial nature, nuclear energy is singled out for a demonstration of the evaluation of risk and benefit. The range of application of nuclear energy is presented. Uses include industrial, medical, and agricultural, as well as the production of electric power. Interrelationships between application, especially commercial and defense, are dawn. A sense of history and the significance of the Manhattan Project are presented. Political, managerial, and media failings are described using the topics of nuclear waste management and the response to the accident at Three Mile Island[5].

Students from different academic disciplines receive quite different benefits from the confrontational approach. Some begin reading more discriminatingly. Some explore what seems to them a "solution" to the energy crisis only to find it somewhat flawed. Most recognize a need for a broad understanding of energy-related principles and the way they affect their lives.

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26.4

COMPARATIVE APPROACHES TO ENERGY EDUCATION FOR THREE DIFFERENT AUDIENCES

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Abstract

This year, different energy programs implemented at Virginia Tech serve the general population in a home environment, students in an academic environment, and professional energy managers in industrial and commercial environments. The general population program consists of correspondence courses carried by local newspapers. The program for energy managers is a four-week diploma program

designed to assist in the establishment of permanent corporate energy management programs. The energy course for students thoughout the colleges at Virginia Tech is designed to increase their knowledge of the technical, environmental, and political aspects of energy.

Introduction

The national and personal importance of energy has motivated the mechanical engineering faculty at Virginia Tech to promote coordinated energy educational activities for individuals outside their department. Two objectives are sought. First, comparative viewpoints are illustrated, whether comparing technologies and resources like solar and nuclear or comparing pespectives like technological and sociological. Second, an awareness of the natural and economic forces which underline the energy discussion and of the different energy-related units is provided.

Much of the information available on energy is specific and disjointed. Articles on specific energy sources claim an answer to the total energy problem. Ignoring economics or priorities, energy conscious homeowners embark upon a program to add an alternate energy source. An engineer, suddenly responsible for reducing corporate energy consumption, deals with brochures offering conferences and short courses on specific subjects that may or may not be among his top energy conservation priorities. Students are interested in an alternate energy sources and specialize without a full understanding of the whole energy picture. Energy-related material available to all segments of society is often overloaded with information, confused by units, overwhelmed with statistics, lacking in an awareness of underlying forces, and devoid of pertinent history. Three specific audiences are addressed through three programs which provide an information base on energy for better decision-making. With no such base, decisions can involve more emotion than fact. These decisions are further carried into the political arena which effects legislation.

One of the three programs consists of a series of newspaper courses available for credit upon demand. The second program is a series of short courses for professional energy managers which prepares them for implementing corporate energy evaluation and conservation activities. The third program includes introductory energy utilization courses which are presented university-wide to undergraduate students at all levels.

Correspondence Courses

The program directed toward the general audience is designed as correspondence courses to be carried by newspapers throughout the state. In order to have good access to the newspapers and local populations, the program was implemented through the Extension Division of Virginia Tech, which has a unit office in each county and city within the state.

Five separate courses are planned to make up the complete correspondence course program. These are: Energy: An Overview, Conservation, Nuclear Energy, solar Energy, and Wood energy. Figure 1 lists individual lessons under each course. To date, the first three have been prepared and the first two have been submitted to the newspapers.

The courses were prepared by a professional journalist hired specifically for the project. The journalist put the information in the language and style appropriate for the general public and assisted in dealing with the newspapers. Technical input was provided by experts within the department who also reviewed final copy for technical accuracy. The extenion agents administered the courses in their locale by approaching the newspapers, corrdinating materials, and conducting testing and credit certification activities.

A preliminary survey showed that about half of the newspapers in the state serving about half the state areas were carrying the first courses. Other uses of the courses included high school presentations, energy fairs, extension radio programs, regular extension columns, extension newsletters an circulars, 4-H groups, and a supplementary course for high school students. Further details are available in reference 1.

Energy Management Diploma Program

The energy management diploma program was started at Virginia Tech in order to meet a need expressed by engineers, who, more and more, are being given the assignment of reducing energy consumption within their organization. Many need to develop new skills, while others simply need to sharpen up those they already have.

A program was needed to help provide professionals with a better understanding of organizational requirements and economic assessment, as well as the technical aspects of processes that require energy.

While preparing the program at Virginia Tech, contact was made with the Energy Technology Center at the University of Wisconsin which was also planning such a program. After comparing the programs, a cooperative agreement between the two universities was developed which has led to a recognized standard of training for energy managers. It consists of four one-week courses and a comprehensive exam. The cooperative effort prevents duplication of effort and standardizes the educatioanl need of energy managers. Credibility at the national level is more easily established. The combined program provides greater flexibility in scheduling the courses and increased quality and quantity of instructional staff. Anyone desiring individual courses is welcome, but there are qualifications to be met before they can be enrolled in the diploma program. The diploma is awarded after completing all four courses and passing a six hour comprehensive exam.

26.5

COMMUNITY ENERGY POLICY PROJECT*

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Abstract
A citizen-based "grass-roots" program for the development and analysis of community energy policies has been developed and applied with success in Ohio. The program emphasizes citizen input and employs the nominal group process to build consensus. Small group discussions are used to generate solutions to local problems which arise from increasing energy costs and resource scarcities. A computer model is used to educate participants about the consequences of continuing historic energy use patterns and to analyze the potential impacts of policy choices on community lifestyle. Policy analysis is performed by a cross-impact procedure and results are graphically displayed for instantaneous feed-back to participants.

The program has intrinsic educational value and is practical both for the offerers as well as the participants. It can lead to the development of policies and actions which are both supported and promoted by local citizens; alternately, it can be used to elicit citizen acceptance of and participation in an already-enacted community energy plan. The program has been used with success in six counties of northwest Ohio where it has led to the development of community energy action plans, citizen energy task forces, and improved energy awareness. The general procedures, techniques for implementation and results of the Ohio program are described.

Background and Need
In the book *Energy Future,*[1] Stobaugh and Yergin allude to the frustration and virtual impossibility of developing understandable and acceptable national energy policies in the face of conflicting and often contradictory information from scientific and expert sources. Indeed, these authors go so far as to suggest that citizens should not expect rational policies in such an atmosphere, and they identify the energy crisis more as a crisis of our political system than one of resources. In the United States, as in many other countries, we are painfully aware of such political controversies in matters involving energy - *e.g.* nuclear vs. non-nuclear electric generation; environmental protection vs. regional development; price controls and regulation vs. free enterprise; ownership and control of energy resources vs. social equity; etc.

In an atmosphere of conflicting and contradictory information, the opportunity is great for proprietary interests to prevail and for policy choices to be made on other than rational grounds. The incentive to maintain the status quo is enchanced, and the likelihood of effecting rational citizen response to impending change is diminished. Such difficulties are discussed by Botkin, *et al*, in the Club of Rome Report,[2] where "maintenance" learning is distinguished from "innovative" learning. In their definition, societies traditionally are conditioned to "maintenance" learning, *i.e.* to a process whereby individuals learn established rules and procedures for dealing with known and recurring situations in order to *maintain* the status quo. Society adapts to the new situation only as much as necessary, crisis situations prevail, and the individual suddenly is controlled by external events. Accordingly, we have learned to develop and accept a sort of "crisis mentality" and have established political and social structures to deal with events on this basis.

In contrast to adaptive behavior, Botkin, *et al* suggest that a new type of learning, *anticipatory* learning, is necessary to minimize irrational reactions to unexpected catastrophic events. A key element in developing anticipatory learning is *participation* by citizens in decisions which affect their future. For example, the establishment of values and priorities in the use of energy resources is an area of decision-making which should involve the affected citizens. More often than not, such decisions are local in nature, and involve value judgements which may not be transferred easily from one community to the next. Participation by local citizens in such decision-making is crucial to the creation of meaningful and acceptable public policies.

To involve citizens substantively in energy policy-making activities, information about the issues must be provided from credible sources. Participating citizens should have an opportunity to discover solutions for themselves and to build consensus. An opportunity to explore the consequences of their own decision-making also should be included. The Community Energy Policy Project described below contains all of these features. Through the use of group process techniques an computer simulation, it provides a means both for developing consensus and for evaluating the consequences of selected policy options.

The Ohio Community Energy Policy Project
The Ohio Community Energy Policy Project was conceived in 1978 and initiated in the Spring of 1979 with the assistance of a grant from the Community-Service Continuing Education Division of the U.S. Office of Education. Project interdisciplinary staff included five faculty from Bowling Green State University, advisory panels from local communities and graduate assistants who managed the computer programming and group dynamics exercises. From May, 1979 through March, 1981, one regional, six community, and several follow-up workshops and seminars were held on the campus of BGSU and at other sites throughot northwest Ohio. Over 350 citizens were involved in the local workshops which are the focus of this paper.

The Kane Policy Impact Analysis Simulation Procedure (KSIM)[3] was used in the workshops to focus discussion and as a means for analyzing current lifestyle, trends, and probable effects of the decision-making process. Using KSIM the consequences of selecting various policy options can be displayed instantaneously and graphically. A time scale of 20 years was used to assess the impacts of the proposed policies.

The Procedure
A. **Limiting the Problem**
To limit the scope and geographical boundaries of the problem, the county was selected as an appropriate geographical and political subdivision. This decision was prompted partly by the manner in which data was available. Different orientations within the same county

proved to be a minor problem. For example, residents in the eastern half of one county primarily were factory workers who commuted to the nearby city of Toledo for employment; residents of the western half were principally farmers. Such inconsistencies surfaced in several instances, but none threatened the program's success.

B. **Community Lifestyle**
To define current lifestyle for the community, and to provide a consistent basis for analyzing historical trends and measuring the results of policy implementation, a set of variables was developed to reflect the socio-econonomic and cultural atmosphere of the locale. Citizens from 12 countries in northwest Ohio assisted project staff in developing a suitable list of eight items. These are noted in Table 1 and were selected from about 60 socially relevant lifestyle elements which were suggested.

Obviously this list does not exhaust the possibilities, nor does it necessarily represent the optimum set of variables for describing a particular community. Rather it is a reasonable set of sociological factors which may be used as a basis for establishing current status and for measuring change. Some of the factors are easily quantifiable; others are not. The KSIM procedure permits the user to include both objective and subjective variables within the same model.

C. **Defining the Variables**
Once the lifestyle factors or variables are identified, precise definitions must be created, and associated data collected, in order to define the range and initial value. Some factors such as *population* permit reliance on quantitative data for their definition. Other factors such as *social harmony* must be based on subjective judgement.

To prepare the lifestyle factors for computer input, a dimensionless relative scale of (0-1) is used. The procedure for doing this is well-described in Kane's original paper and elsewhere.[3-6] Reasonable high and low limits for each variable are identified from historic trends, and the current value represents the state of the variable as a fraction of the (0-1) range. An initial value of .75 therefore would represent a starting point of 75% of the defined range. Note that zero on such a scale does not represent zero in an absolute sense but rather just the minimum value for the defined range.

Some of the sources used for defining lifestyle variables are listed in Table 2. Source reliability varies greatly, so these must be used with discretion. Often one community must be compared to others that are similar. For example, the crime rate in urban countries should be compared to other urban areas of similar population, not to rural or suburban counties with vastly different lifestyles.

D. **Constructing the Basic Model**
Once the variables have been selected, defined, and appropriately quantified, the interactions must be described to develop a model of system changes over time. The KSIM model used in this study is a simple deterministic simulation procedure which uses a set of first order non-linear differential equations to describe the system evolution. KSIM is not the only model which can be employed. In fact the program can be duplicated without any model. However; models are a convenient and useful tool for focusing discussion, limiting the problem, educating participants, and illustrating impacts in graphic form dramatically and rapidly.[7]

The KSIM model takes into account the binary interactions between system variables through the use of a fixed "cross-impact matrix". This matrix, which becomes a focal point for group discussion, is simply a table of numbers whose values represent the directions and strengths of interaction between system variables. Working in small groups, participants in the Ohio program initially assigned values for the elements of this matrix. In this way, the model incorporates the perceptions of local citizens as to the status and interrelatedness of the lifestyle factors.

Elements of the impact matrix were limited to values of 1,2, or 3 to represent weak, moderate, or strong interactions, respectively, between system variables. Positive or negative entries represent enhancing or inhibiting influences, and zeroes denote no interaction at all. Fractional entries represent averages form the reporting groups. The matrix elements and initial values of the system variables are used as input for the KSIM computer program. The compter numerically solves the equations and provides graphical output. This set of graphs is referred to as the base case model because it represents a no-action, status-quo model and a baseline against which the result of action programs can be measured.

E. **Interpreting and Using the Model: Incorporating Policies**
To analyze the effects of implementing a chosen policy or action program, the model is expanded by adding columns to the impact matrix to allow for inclusion of policy options. Again, entries in these new columns are developed through small group discussion during the workshop. Policy discussions focused on four central themes:

1) Alternate energy sources
2) Energy education
3) Conservation
4) Transportation alternatives

Participants were required to develop a rationale for each policy recommendation and to suggest actions for local implementation. Small group discussion leaders assisted in evaluating the relation of individual policies to the set of lifestyle factors.

The Ohio Experience
Six counties in northwest Ohio were selected for community workshops. Workshop sites were selected on the basis of local interest. They were held in urban, suburban, and rural locales, representative of the region. Thirty to forty citizens attended each workshop. Participants were recruited to represent all facets of community life. Prior to each workshop, project staff members met with a local planning committee to request assistance and to determine unique features and issues of local concern. One week before the workshop, resource packets were sent to participants containing definitions of lifestyle factors, local statistics and a base-case model pertinent to their county.

At the workshop, participants were divided into small groups of 6-8 persons and were assigned at least one of the four general policy areas. Each group discussed, and through consensus, developed specific programs for their community. Each small group was moderated by a leader from the BGSU School of Speech Communication trained by the project staff. Policies developed in small groups were reported to the main assembly in order to share information and to obtain feedback and critique from the total audience.

The KSIM cross-impact matrix was used to assess the impact of each proposed policy on the lifestyle variables. These data were fed into the computer for immediate feedback. The computer produced on-the-spot graphical outputs which were compared with the base-case model graphs. Participants could then judge for themselves the potential effects of implementing the policies. After viewing the graphs, participants were given an opportunity to modify their policy choices. In this way, the computer simulation enabled participants to prioritize and develop more acceptable policies.

Results of the Ohio Program

An abbreviated list of policy and action programs suggested by participants at these workshops is given in Table 3. Many recommendations were made by more than one group. Overall, workshop participants felt there was a need for increased public awareness about energy and more credible information on current energy issues. Many voiced distrust in government or energy-supply industry plans to solve their problems. Most policies reflected the need to use formal and informal educational institutions and tools to increase awareness, and to provide practical information as a basis for informed decision and action.

While many felt that only economic incentives or sanctions would motivate increased conservation, the need for lifestyle adjustments and value changes also was stressed. Participants felt that conservation efforts and alternative energy development should be viewed in a more positive manner. In this way, conservation would arise from voluntary compliance rather than through a mandated restriction of choice.

Sample recommendations are listed in Table 3. The general results may be summarized as follows:

1. **Alternate energy sources:** For most communities the use of such sources is considered too long term to be of benefit for the solution of problems of immediate concern. Currently available alternate fuels are generally not considered cost-effective. The most common suggestions for stimulation of alternate fuel development were tax incentives and low interest development loans.

2. **Energy Education:** All workshop participants felt that education, both formal and informal for all ages, would increase public awareness of energy supply, use, and available alternatives, and also would create a more positive public attitude towards action. The most prevalent suggestion for formal education was to introduce energy curricula in grades K-12 - also in adult education and in technical schools and universities. Media and speaker bureaus were suggested to help to put practical energy information in the hands of the people.

3. **Conservation:** Participants viewed conservation and improved energy efficiency as necessary for managing current energy use. Building code modifications, community conservation goals, and public recognition for conservation efforts were recommended to promote energy efficiency.

4. **Transportation:** Participants favored public transportation systems, van and carpools for employees. They recommended efforts to change public attitudes so that biking and walking would be enhanced and unnecessary auto use discouraged.

Summary and Conclusions

We feel these workshops and the associated processes are unique and beneficial for adult education and citizen involvement programs. Not only does the process develop a meaningful list of policy recommendations for community action, but it also produces a highly informed group of local citizens who are more receptive to peer judgement, more aware of energy problems as they relate to personal lifestyle, and who are more likely to participate in future community activities. Since the policies selected are produced from small groups representing typical population segments of the community, the recommendations are representative of local needs and should be acceptable at that level.

Implementation of the proposed policies rests with the citizens in the communities and with the respective bodies of authority. Following each workshop in Ohio, copies of the policy recommendations along with an analysis of the likely impact were sent to local and regional government officials. Some local suggestions have resulted in long range actions. Continued contact with the local groups has been fragmentary but positive. BGSU continues to assist these communities as a part of our institutional mission of service to citizens in this region.

For those who would be interested in developing a similar program, the Energy Studies Program at BGSU has developed a *Training Manual* to assist in the planning and execution of such a workshop. This manual may be ordered from: Energy Studies Program, 313 Hayes Hall, Bowling Green State University, Bowling Green, Ohio 43403. Telephone: 419/372-2624.

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TABLE 1

Lifestyle Factors Used in the Ohio Project

Population	Social Harmony
Employment	Environmental Quality
Education	Family Energy Expenditures
Community Services	Transportation

TABLE 2

Data Sources Useful for Assessing Lifestyle Factors

Factor	Source
Population	U.S. Census Report City-Country Data Book Survey of Buying Power Planning Commission Documents
Employment	Bureau of Employment Services Chamber of Commerce Planning Commission Reports
Education	State Dept. of Education National Education Association Discussions with local residents and school officials National Center for Education Statistics
Community Services	Local Service Agencies Planning Commission Community Action Commissions County Health Department Parks and Recreation Welfare and Employment Agencies
Social Harmony	Chamber of Commerce Local Government Local Enforcement Agencies Comminity Action Commissions Crime Statistics Local Newspapers Labor organizations
Environmental Quality	Regional Planning Commission Regional EPA Office Audubon & Sierra Clubs Parks & Recreation Commission County Extension Agent League of Women Voters
Energy Expenditures	Statistical Abstract of U.S. State Department of Energy Department of Commerce

Transportation	State Dept. of Transportation Bureau of Motor Vehicles State Department of Energy Chamber of Commerce Planning Commission Reports

TABLE 3

Sample Policy Recomendation·of Ohio Programs

Policy Category	Recommendations
Alternate Energy Sources	Property and municipal income tax incentives for solar, wind, biomass, recycling Low interest loans for alternate energy source private sector investors Local citizens groups to provide energy audits, workshops, feasibility studies Favorable zoning and building codes
Energy Education	Energy education K-12 Expansion of technical energy courses in all post-secondary and corrrespondence institutions Local energy awareness seminars and workshops for all Business supported scholrships for energy resource development Energy information articles in local media Speakers bureau and energy information center Energy events calendar featuring energy fairs, tours, forums
Energy Conservation	Conservation clearinghouse to disseminate pamphlets, etc. Annual awards for energy saving in residential, commerical and industrial areas Display of architechtural designs that conserve energy in public buildings and newspapers Development of a model energy conservation community Waste heat conversions for commercial or residential heating
Alternate Modes of	Community supported public transport system Transportation Car and van pooling incentives Sidewalk maintenance Publicity to encourage walking and biking Construction of satelite commuter parking lots, bikeways and bicycle parking Mini-or shuttle-buses for central area transport Staged elimination of private vehicles in congested areas

SESSION 27: SCIENCE AND TECHNOLOGY

27.1

Ocean Thermal Energy Conversion as a Vehicle
for the Teaching of Thermodynamics

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Abstract
OTEC plants are huge heat engines, and as such can be effectively used to illustrate many principles of thermodynamics such as kinetic theory, change of state, thermal conductivity, the first law of thermodynamcis, and heat engine efficiency. A brief description of OTEC power plant operation and numerical examples are given.

Text
Ocean Thermal Energy Conversion (OTEC) is a solar technology and thus it is a renewable energy source. The oceans are enormous storage tanks for solar energy and the collected energy is essentially available twenty-four hours a day. This places OTEC in a unique position among renewable power systems: it can be used for base-load power.

OTEC is a huge heat engine that utilizes warm surface water as a heat source and cold water in the depths as a heat sink. Proposed power plants require at least a 15°C temperature gradient and extend 500 - 1000 meters below the water surface. [1-3] There are two basic OTEC designs: closed-cycle and open-cycle.

The open-cycle OTEC pumps warm surface water through a short pipe and flash-evaporates it in a partial vacuum. The resulting steam turns a turbine-generator to produce electricity. The steam is then cooled in a condenser by cold water pumped in from the depths. The working fluid is seawater.[4]

The closed-cycle OTEC uses ammonia, propane, freon, etc., as the working fluid.[5 6] Because these fluids boil at a lower temperature than water, heat from the warm surface water is transferred to the working fluid in a heat exchanger (evaporator). The vapor turns a turbine-generator and produces electricity. The vapor is cooled and condensed by cold ocean water in another heat exchanger (condenser). The working fluid is then reused in a closed cycle.[7]

There are many technological problems to be addressed such as biofouling, materials research, etc,[8] but it appears that OTEC has a bright future in world energy production, at least as far as cost analysis is concerned.[9]

The point of this paper is that OTEC is an interesting illustration of several thermodynamic principles suitable for use in a high school or college classroom. In addition to becoming familiar with a power technology destined for wide future use, students can see in action concepts they have seen theorized in lecture. Further research on the students' part is possible, because there are several working models available off the coast of Hawaii[10] and Japan. Some basic principles that can be effectively exemplified through the use of OTEC are: kinetic theory, change of state, thermal conductivity, the first law of thermodynamics, and heat engine efficiency.

On a basic level, kinetic theory, change of state, and thermal conductivity can be illustrated very nicely by following the closed-cycle working fluid (say ammonia) through a complete cycle. As the ammonia liquid comes into contact with higher temperature materials in the evaporator, the average kinetic energy of the ammonia molecules increases (temperaturel). When enough heat energy has ben absorbed, the liquid boils or changes state to a gas. The extremely low thermal conductivity of liquids provides the basic problem of evaporators. (Large heat flux rates across heat exchange surfaces ar needed, but the flux from the boiling side of the heat exchange surface to the liquid-vapor interface is driven by a small temperature drop. This necessitates a very thin slab of still ammonia, much thinner than that available in practice. Convection and nucleate boiling could be discussed here as methods of minimizing the role of liquid thermal conductivity.) Some of the heat energy of the vapor is then changed to kinetic energy of the rotating turbine and then to electrical energy in the generator. In the condenser the amonia vapor comes into contact with lower temperature materials and changes state back to a liquid which is than pumped back to the evaporator to close the cycle. There are numerous opportunities here to emphasize principles previously discussed in class.

The first law of thermodynamics can be illustrated semiquantitatively using the open-cycle OTEC design. If it is assumed that the warm surface water is cooled 5°C during evaporation, the heat energy available for work per cubic meter of water would be

$$Q = 1.0 \times 10^3\ kg/m^3 \quad \times 1 m^3 \times 4180 J/kgK \times 5K = 2.1 \times 10^7 J = 5000\ Kcal$$

If the surface water averages 25° C, the heat energy available per cubic meter is $Q = 1.0 \times 10^3$ kg x 4180J/kgK x 293.3K = 1.23×10^9J. Thus, of 1.25×10^9J of heat energy entering, 1.23×10^9J is ejected and 2.1×10^7J is available for useful work.

Finally, the efficiency of a heat engine is effectively illustrated by analyzing the various components of an open-cycle OTEC design. Assuming a 100 MW plant with a 93% efficient turbine with a water rate of 1.52×10^5 lb/min, the system losses are[11]

evaporator	27.61 MW
cooling water circulation pump	12.55 MW
deaerator	0.61 MW
fresh water pump	0.12 MW
total	40.89 MW

Therefore, this plant will produce 59.11 MW net electrical output. The maximum thermodynamic (carnot) efficiency for a heat engine is eff $= (T_H - T_c)/T_c$. The temperature difference in efficient systems is hundreds of degrees, but in a typical OTEC example the warm water at 30° C is condensed at 15° C. The maximum efficiency for the steam cycle then is eff = (298K - 288K)/298K = 3.3%. When practical losses are counted, the efficiency will be less than 2%; this means that an ocean thermal plant must transfer ten times as much heat energy as a typical fossil fuel generating plant.

The above are just a few samples of what you can do with OTEC examples in the classroom. Let your imagination run free!

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27.2

INTEGRATED ENERGY EDUCATION IN GENERAL CHEMISTRY

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Winslow H. Hartford has written:

"Perhaps the time has come to refine the role of Chemistry, and of Science in general, in a society whose effective operation depends on appreciation of the true function of Science. In such a society, Science becomes a partner rather than a tool, of the political and business communities in meeting the challenges of energy and raw material shortages and of a deteriorating environment."[1]

We should present to our students science that not only provides the requisite theoretical background for further work, but which also is relevant, interesting and practical. What better way to capture a student's attention than by applying simple chemical tools to a pressing societal problem.

Ask your students to consider the marketability of a new fuel system that could:

1. Make more efficient use of the existing sources of energy.
2. Eventually lessen our dependecy upon foreign fossil fuel imports.
3. Make more feasible the application of "soft technologies" to produce energy (solar, wind, tidal, geothermal, etc.).
4. Create a potential for developing countries that do not have significant fossil fuel reserves to become energy self-sufficient.
5. Make feasible the decentralization of production and economic control of energy, creating a dynamic universal market for clean energy resources.
6. Reduce enviromental pollution from energy production to the pre-industrial levels of the 18th century by substituting a clean fuel source for the high pollutant hydrocarbon sources (petroleum and coal).[2]

Such a proposal will arouse student interest in this innovative energy source. The ensuing lecture will utilize basic chemical principles to evaluate HYDROGEN as the proposed energy source. the evaluation serves to integrate and utilize these fundamental principles to present a solution to a contemporary and familiar problem.

For the past several years, the Department of Chemistry at the United States Military Academy, has been presenting a lecture entitled "A Look at Hydrogen" as part of the Basic Chemistry course. The purposes of the lecture are threefold:

1. To demonstrate the relevancy of chemistry.

2. To introduce some needed descriptive chemistry to our general chemistry course.
3. To review and synthesize several chemical principles taught in the general chemistry course.

The lecture changes upon each presentation based on the interests of the lecturer and publication of new information on hydrogen energy. At the time of the lecture the students have had about thirty attendances of general chemistry and have discussed most of the principles presented in the lecture. The demonstrations that are used throughout the lecture are effective, pedagogically sound and, in some cases, spectacular. These demonstrations are described at the appendix to this paper.

An outline of the lecture is given here:

I. *Introduction.* Any dramatic "attention-getter" can be used. (Igniting hydrogen filled balloons is effective in any format.)
II. *Background.*
  A. Occurrence
    1. Solar system
    2. Earth
  B. Isotopes
  C. Molecular Hydrogen's Physical Properties
    1. Density (Several interesting demonstrations are possible for density. They can be spread throughout the lecture as much as format permits. See appendix for Demonstrations 1 through 4.)
    2. Melting/Boiling Point
    3. Phase Diagram
    4. Ignition Temperature
    5. Combustibility (See appendix for Demonstrations 5 and 6. Demonstration 6 also illustrates ignition temperatuare.)
  D. Common Uses/Reactions
    1. Redox (See appendix for Demonstration 7.)
    2. Haber-Bosch Process
    3. Production of Methanol
    4. Arc welding
    5. Petroleum refining
    6. Petrochemical manufacture as feedstock
III. *Fuel Evaluation.*
  A. Preparation
    1. Laboratory
      a. H_2 Generator (See appendix for Demonstration 8 on the construction of device which produces H_2 gas from a metal-acid reaction on demand.)
      b. Active metal in H_2O (Hydrogen bubble formed in the Three Mile Island incident.)
      c. Electrolysis (See appendix for Demonstration 9.)
    2. Industrial Scale
      a. "Spongy" Iron catalysis
      b. Steam reforming
      c. Water-gas shift reaction
      d. Electrolysis
      e. Thermochemical decomposition of water
        (Water is emphasized as the feedstock for a. through e. above.)
  B. Transportation of Hydrogen
    1. Pipeline gas
    2. Liquid hydrogen
      a. Advantages
      b. Disadvantages
    3. Metal hydride (See appendix for Demonstration 10 showing diffusivity into porous material.)
  C. Suitability as Fuel
    1. H reaction for $2\ H_2 + O_2 \quad 2\ H_2O$
      (compare to H reaction for $CH_4 + 2\ O_2 \quad CO_2 + 2\ H_2O$
    2. Catalyzed reaction (See appendix for Demonstration 11.)
    3. Fuel cell (A hydrogen powered fuel cell is available commercially for demonstration and is used as Demonstration 12.)
    4. Fusion
    5. Upgrading oil shale
    6. Synthetic gas
    7. In transportation industry vs. electric car
  D. Use of hydrogen vs. conventional fuel systems
    1. Advantages
      a. Supply
      b. Environmental Impact
    2. Disadvantages
      a. Safety (compare to methane)
      b. Public opinion (The Hindenburg incident gave hydrogen a bad reputation with the general public - film clips of this event are commercially available.)
      c. Cost of production

The topic selection and format of presentation are flexible. The lecture effectively shows the students how much they have learned in chemistry and how to utilize these fundamentals. The student reaction to the presentation has been extremely favorable. Students frequently remark on its value in the end of course critique and occasionally ask to attend the next semester's presentation. Years later students still remark about the fact that they recall the "Hydrogen Lecture." Perhaps it is most important that the students understand that they can easily use their chemistry fundamentals to investigate a complex subject of contemporary interest - energy.

Appendix — Description of Demonstrations

Demonstration 1: Two balloons, one filled with hydrogen and the second with air are fastened together with string and released to demonstrate variation of density.

Demonstration 2: A subject talks normally and then inhales helium (helium replaces hydrogen for safety) at atmospheric pressure and talks again. The low density of helium (although twice that of hydrogen) causes a voice change. This can be done by filling a large, clear plastic bag with 20% oxygen and 80% helium. A subject can place the bag over his head, breathe the mixture and then remove the bag and talk.

Demonstration 3: A balance has one pan replaced by an inverted bell jar and the second pan holds a beaker of sand that exactly levels the scale. When hydrogen is "poured up" into the bell jar, the scale tips showing that the hydrogen density is less than the air it displaces.

Demonstration 4: Two metal cones are fused at the bases. The apex of the bottom cone is cut off and small holes are drilled near the top of the upper cone. The device is filled with hydrogen and is ignited at the upper holes. As hydrogen is consumed at the flame, air is drawn in the bottom opening. The device is affectionately called a "mosquito cup" due to the mosquito-like buzzing sound made by the gas flow around the holes. The mixture reaches stoichiometric proportions of hydrogen and oxygen, with increasingly loud buzzing, and ignition occurs. The device must be held away from the subject and with the bottom opening aimed down.

Demonstration 5; Balloons of air and hydrogen respectively are burst with a flaming taper to shown combustion.

Demonstration 6: Into an inverted bell jar filled with hydrogen, insert a flaming taper. The gas interface ignites with a mild but noticeable "pop" and, as the taper penetrates further into the hydrogen, it goes out. Slow withdrawal of the taper relights it at the interface. This demonstrates ignition and the inability of hydrogen to support combustion.

Demonstration 7: Copper metal is oxidized by heating in the open atmosphere producing a dulling copper (II) oxide coating. covering the copper with an inverted jar filled with hydrogen provides an environment conducive to the reduction of to Cu metal with an instant and dramatic change in luster.

Demonstration 8: Hydrogen is generated by immersing zinc into hydrochloric acid causing hydrogen gas generation. The hydrogen gas fills an inverted inner cylinder and as the pressure increases the HC level is forced down below the level of the zinc stopping the reaction. The inner cylinder is tapped on demand to provide hydrogen, allowing the HC level to rise and restart production.

Demonstration 9: A Hoffman electrolytic device is activated and the hydrogen and oxygen collected at their respective electrodes. Dye is added to the water, and the resulting desplacement clearly demonstrates Gay-Lussac's Law. (This demo can be started and returned to later as it requires several minutes for noticeable results.) With careful recombination, the mixture can be reignited to demonstrate its reversibility.

Demonstration 10: A closed container is filled half with dye colored water and half with air. A small tube runs out of the liquid up into the outer atmosphere acting as a safety valve. A small tube exits the top of the device and is sealed by a porous ceramic cup. If a beaker of hydrogen is inverted over the porous cup, liquid is forced out the safety valve. The driving force is the overpressure caused from the hydrogen diffusing in faster than the air can diffuse out. This can be related to Graham's Law of Effusion.

Demonstration 11: Hydrogen and oxygen are stoichiometrically combined in a reinforced container and a greased cork is placed over the container opening. A piece of platinized asbestos is heated and gingerly inserted alongside the cork into the bottle. The reaction occurs violently sending the cork bouncing off the ceiling. This must be done with extreme caution.

Demonstration 12: A small hydrogen fuel cell powers a small electric light and an electric motor to driver a propeller.

References:

(1) W.H. Hartford, Emmeritus Professor, Environmental Science, Belmont Abbey College, Letter to the Editor, Chemical and Engineering News, 49, March, 1981.

(2) H.B. Silverstein, Naval War College Review, XXXIII, September-October, 48, (1980).

(3) Diagrams or other illucidations can be obtained from the authors at the Department of Chemistry, United States Military Academy, West Point, New York 10996.

27.3

TEACHING ENERGY

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Abstract

This paper outlines the teaching of energy concepts to students in both technology and business studies programmes. An introduction to energy conversion is taught via a novel graphic device the "Energy Conversion Triangle." A computerized energy model for the UK is discussed, which allows students to see the implications of adopting various energy policies. Student exercises using the model suggest that there is no definitive solution to our energy problems, and that a balanced view must be taken by the energy planners of the future.

Introduction

The realisation of the finite life of fossil fuels has led to a greater emphasis on Energy Education. The ordinary citizen is no longer willing to rely solely on the engineer or scientist to decide future methods of energy supply; they want to be part of the decision making process. People are concerned with the environmental effects of energy conversion, the cost of energy and how it will effect their life-style if it is not made available. Teaching methods are thus required which can explain in simple terms the complex processes of energy conversion and the balanced energy mix necessary to supply our future needs. This paper describes teaching energy to undergraduates in technology and business studies programmes within the department of Mechanical and Production Engineering at Sheffield City Polytechnic, England. Although these students have a greater technical knowledge than the lay person some of the techniques used are successfully applied to non-technical courses. The introduction to energy conversion is through the use of a novel graphic device, the energy conversion triangle.

The Energy Conversion Triangle

This device shows the types of conversion processes available and also illustrates the dilemma between high cycle efficiency and power density requirements.

Thring[1] in 1962 used an energy conversion diagram to illustrate a new route for electrical production, magneto-hydrodynamics. His diagram was incomplete and only showed one route for stored energy to mechanical energy. The authors have expanded this diagram and renamed it the Energy Conversion Triangle. Commercially produced conversion diagrams are available but they are usually too complex for use in introductory lectures.

The Energy Conversion Triangle is best taught using an interactive teaching method. Part of the diagram is drawn and labelled with the three principal energy forms. The students are then asked to name types of stored energy and devices to directly convert one form of energy to another. Typical replies from the students detail the following stored energies and devices for direct 'routes' along the diagram;

Stored Energy: Chemical (fossil fuels) Solar

Nuclear Wave

Potential (high level reserviors, pressure) Wind

Kinetic (rotating flywheel)

Route 1-2 water turbine Route 2-1 pump

Salter duck wave generator

windmill, aerogenerator propeller

Route 2-3 dynamo Route 3-2 electric motor

alternator linear motor

Route 1-3 fuel cell Route 3-1 electrolysis

battery electro-deposition

If students mention routes involving heat these are discounted as they are not direct routes.

The next stage is to complete the diagram with devices with employ the 'heat routes.

Again, typical replies from students detail the following devices for heat routes along the digram;

Route 1-4 solar panel Route 4-1 dissociation

combustion

nuclear fission/fusion

Route 4-2 steam/gas turbine Route 2-4 friction
piston engine

Route 4-3 magneto-hydrodynamics Route 3-4 electricial resistance heating

thermoelectricity induction heating

thermionics

Conversion Efficiencies

Students are then asked the key question: What are the efficiencies of conversion from one form to another? Discussion will reveal that many routes have theoretical efficiencies of 100% and achievable efficiencies greater than 90%, ie electric motors, pumps, water turbines, batteries etc. The route that many students estimate incorrectly is the one used by conventional thermal power stations which have generating efficiencies of less than 35%. At this stage notes can be given to the students with an explanation for the low efficiencies for routes 1-4-2, 1-4-3.

Points to be made to Emphasise the Significance of the Heat Route

Mechanical energy can be completely and continuously transformed into heat by friction and similarly electrical energy can be transformed to heat with 100% efficiency. Heat on the other hand *cannot* be converted to mechanical or electrical energy with 100% efficiency. The second law of thermodynamics which led from the work of Carnot[2] in 1824 states that some energy must inevitably be rejected. The highest achievable efficiency for conversion of heat to mechanical or electrical energy via routes 1-4-2 and 1-4-3 is given by the Carnot efficiency.

When fuel was relatively inefficient route could be chosen as the fuel cost would only be a fraction of the total cost. As fuel prices have risen the efficiencies of power stations have improved to offset the additional fuel cost element. Table 1 gives the average overall efficiencies of thermal power stations in the UK.

At this stage lectures are given in the basic thermodynamic cycles, the Carnot and Rankine cycle etc. This leads to the modifications made to the Rankine cycle to improve efficiency. It is then shown that the generating efficiencies of modern thermal power stations are unlikely to improve appreciably in the near future while the cost of fossil fuels will increase rapidly and the availability will decrease. The next question to be answered is " why do we continue to use such an inefficient route?" In answering this question the concept of power density can be introduced.

Power Density

The power density is defined as the rate at which energy crosses a square metre of heat exchanger surface. When students are asked to estimate the power density of a fossil fuel boiler most if not all have no idea. With a little practice and help the students can arrive at a reasonable guestimate. The larger power stations in the UK are rated at 2,000 MW electrical output; hence the students can deduce a nominal fuel input of 6,000 MW or 1,500 MW for each of the boilers. A boiler would comprise the furnace, superheater, reheater and economiser. The major difficulty for the students is to estimate the amount of steam tube inside the boiler combination. Having been shown cross-sectional views fo the boiler many students will accept a value of the order of 100,000 m^2. In practice power densities of 50,000 watts/m^2 can be achieved with fossil fuels.

Students can then make comparisons with other devices. In the UK the daytime average for solar radiation is approximately 200 watts/m^2. Thus the students can see that solar power stations would have to immense areas to have the same power output as conventional ones and that the savings in fuel would not justify the initial capital cost at current fuel prices. This illustrates that plants with high power densities are therefore compact resulting in low capital and operational costs.

Nuclear power stations have power densities similar to fossil fuel power stations; the fuel handling charge is greater but the overall running costs are less due to the low cost of the fuel.

Other devices which can be discussed are windpower, which only has a power density of 400 watts/m^2 and wave power which can have power densities of several thousands of watts/m^2 over the first several metres of depth of water. Fuel cells now have generating efficiencies approaching 70% and can have power densities of 600 watts/m^2. Unlike wind and wave generators they can operate at maximum power anytime and do not rely on natural forces which can vary considerably.

Energy Modelling

The type of energy conversion device used does not depend solely on the most economical method. Other issues must be considered: security of supplies, overseas trading balance, environmental effects, safety etc. Many students have preconceived ideas on these issues, the two most popular being (i) the waste of valuable resources (fossil fuels) to obtain heat when solar energy is free and inexhaustible, and (ii) that nuclear power is dangerous and should not be used. Both these arguments are valid to greater or lesser extent but the students must be aware of the consequences of restricting fossil fuels for premium use and the banning of nuclear power. The answer to question (i) is largely one of economics and to (ii) is achieved by the use of energy modelling.

A model of the UK energy usage and supply has been computerised and is so designed that the student can alter various input parameters and see what consequences result in the provision of energy supplies in the future. If say nuclear power were progressively run down over a twenty year period and was replaced by coal burning power stations and the student would then be aware of the logistical consequences of his planning. Could enough new mines be opened, how much coal would have to be transported, could enough power stations be commissioned in time etc? The energy model will not give definitive answers to our future energy needs as it relies on many assumptions to our present and future energy patterns, but it does illustrate the need for a mixed fuel policy. Its main virtue is that it allows the student to see the consequences of his ideas, inputted as forecasting patterns.

Methodology of the Model

In the model energy demands are allocated to four sectors of the economy; the industrial sector, commercial and services sector, transport sector and domestic sector. These sectors require energy supply for heating purposes, energy supply for power and energy supply for transport. The sectors and supplies of fuel are shown in figure 3, secondary choices of fuel being used to top up when a first choice fuel reaches its maximum supply. Electrical energy for the four sectors can be generated from fossil, nuclear and renewable resources, while heat can be supplled from gas, oil, coal, solar, electricity, combined heat and power (CHP) installations and in the future by synthetic oil and synthetic natural gas (SNG).

The link between energy demands and available resources is made by employing a set of 'market shares'. The market shares are user variables and will depend on the forecast of the person using the model.

The computer model evaluates the demand from the four sectors and allocates supplies from the five main fuels (gas, oil, coal, nuclear, renewables). The basic calculation of the model is repeated at time intervals, stretching to the year 2025. The 'forecasting' as such involves changes to market chares, conversion efficiencies etc and 25 user acessible variables which prescribe the four demand sectors. Many variables are allocated internally (in this case 74) in order for the programme to operate quickly. Only the advanced students are encourages to change all the variables.

Any given fuel supply is limited by some factors or combinations of factors, so that the model is constrained to simulate the real situation. eg coal, oil and gas supplies are limited by the lesser of (i) available reserves or (ii) available plant (coal mines, oil and gas wells), plus maximum imports (which are prescribed by the user).

The allocation of supplies to demand will depend on logistical constraints ie electricity will be allocated to those demand sectors that can use nothing else, while substitutes (synthetic oil and gas) will have to be used if the energy source is not sufficient to meet demand. A sequence of allocations of resources to demands is necessary and this may entail up to twenty allocations.

The output from the model will give at five year intervals from 1980 to 2025 the following output:

(i) total demand for energy (Joules/year) in each of the following four sectors:- domestic, commercial and services, industry, transport.

(ii) the supply of energy (Joules/year) from each of the following five sources:- oil, gas, coal, nuclear, renewables.

(iii) imports of fuels (if any) for the fuels:- coal, oil, gas.

(iv) a figure for gross domestic product (GDP). This is a weighted sum of the amount of energy use in each sector of demand.

The model at Sheffield City Polytechnic is based on the UK economy but by suitable alterations to the limiting factors and input data model can be constructed to suit other developed countries or third world countries. To facilitate the initial use of the computer model by inexperienced students two scenarios are stored. One view (scenario 1) has variables and trends set to a 'low energy' future while scenario 2 has a more flagrant use of energy which results in substantial imports of fuel to meet demand after the year 2000.

Suitable student exercises are:-

(i) Using as a base, scenario 1; maximise Industrial and Commercial activity without increasing energy demand and having no imports of fuel.

(ii) Using as a base, scenario 2; maximise GDP with imports of fuel if necessary.

(iii) Using as a base, scenario 2; with no nuclear power and no imports of fuel keep GDP constant.

(iv) Using as a base, scenario 2: using maximum nuclear power and no imports of fuel keep GDP constant.

These exercises illustrate that there are no definitive answers to the problem of energy supply, and that a balanced view should be taken by students to these problems. They also remind the student that energy demands and supplies for one sector are intimately related to those in other sectors and most importantly that technological decisions have social implications. The use and misuse of energy affects everybody all the time.

References

[1] M W Thring, Magnetohydrodynamic power generation, Inst Elect Engs Jnl v8 n89 May 1962.

[2] S N L Carnot, Reflexions sur la puissance motrice du feu sur les machines propres a developper cette puissance (Bachelier, 1824), transl R H Thurston, Am Soc mech Engrs 1943.

Table: Overall thermal efficiencies of UK power stations

YEAR	OVERALL THERMAL EFFICIENCY %
1932	17.08
1937	20.05
1950	21.45
1960	26.53
1970	28.30
1980	31.68

27.4

THE USE OF A SELF-INSTRUCTIONAL SCIENTIFIC LITERANCY MODULE FOR ENERGY EDUCATION

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Abstract

The role of science and technology is increasing throughout our society especially regarding global energy issues. There is a need for all citizens to have a scientific and technical literacy to understand and cope with these energy issues. The purpose of this study was to develop a self-instructional Scientific Literacy Module as a teaching tool. The module was designed to help develop the critical evaluation process of nonscience students on controversial energy issues. By following the steps of the module the student develops critical mindedness and objectivity in evaluating an article or series of articles on a controversial energy issue. The module stresses independent thinking and self pacing. It utilizes a series of objectivies, rationales, readings and learning exercises. An assessment of the module was done on two different groups of college nonscience major students at two different institutions. Group 1 was required to use the module throughout the semester and was given a Scientific Literacy Module Evaluation. Group 2 was given the module but was not required to use it while working on an energy issues project of their choice. Student comments on the value of the module as a learning experience to develop critical mindedness were documented.

Introduction

A recent report to the President of the United States, (prepared by the National Science Foundation and the Department of Education), on the state of science and engineering in the United States has noted that the role of science and technology is increasing throughout our society. Knowledge of science is becoming a key to success in business, government, military, professions, and other occupations where it had never intruded before. Today, people in a wide range of non-scientific and non-engineering occupations and professions must have a greater understanding of science and technology.[1]

The energy situation is an excellent example of a crisis area for which many persons still do not fully understand the long term implications. This is exemplified in a recent National Geographic special report on energy which states: "Americans like to believe that technology will solve any problem quickly if we work at it hard enough and throw enough money at it. After all, we sent men to the moon, didn't we? But in the case of energy such a belief is compounded of wishful thinking and a lack of understanding of the limits of technology when faced with complex and intractable problems."[2]

It has been clearly visible that the economic and scientific segments of society have attempted through the media to develop an awareness on the part of the general public of the energy issue. However, a major responsibility to change attitudes and practices lies in our educational system. Scientific and technical literacy is increasingly necessary in our society, but the number of people who graduate from high school and college with only the most rudimentary notions of science an technology portends trouble in the decades ahead.

Many definitions have been offered for science literacy; for the purpose of this study a four part operational definition proposed by G.T. O'Hearn will be used. The definition was summarized as follows: "1. basic scientific knowledge, 2. nature of science, 3. the processes of science, and 4. social and cultural implications of science."[3] Literacy in science implies not only an ability to read and communicate about the science, but a willingness and, perhaps, even an eagerness to do so. At present, there is some evidence of a trend in the opposite direction within our society. There appears to be a prevailingly negative view of science, a sort of "disenchantment or uneasiness" about science as represented in some technological developments, particularly those that upset the human condition or environmental factors.

The current situation requires the broadening of both the scope of what is taught and expanding the range of students. A viable alternative to creating new courses is more rapid development of supplementary materials which can be incorporated into existing courses. G.T. O'Hearn suggests a strategy is needed which will:

1. Prompt the development of new supplemental teaching materials specificaly directed toward developing science literacy.
2. Be attractive enough to encourage teachers to incorporate the strategy and materials in teaching without retraining.
3. Result in increased literacy in science as defined previously.[4]

This paper deals with the development of a self instructional scientific literacy module as a teaching tool to meet the above described strategy. The module was designed to help develop the critical evaluation process of nonscience students and guide them to become scientifically literate citizens. Students are confronted by a multitude of information dealing with controversial technologies ie. energy, via magazines, newspapers, TV specials, etc. By following the steps of the module the student develops critical mindedness and objectivity in evaluating articles or films on controversial issues, with energy significant among them. The module stresses independent thinking and self pacing. It utilizes a series of objectives, rationales, readings, and learning exercises. An assessment of the module was done on three different groups of college nonscience major students at two different institutions.

Self-Instructional Scientific Literacy Module

The module consists of a series of steps to be followed in sequence; it enables students to critically evaluate any literature relating to science. It was in the interest of developing "scientific literacy" in students that this non-technical approach to critically evaluating the literature was directed. The process of the module fulfills three of O'Hearn's basic components of the definition of science literacy. It helps the student achieve basic scientific knowledge, information of the nature of science and the process of science. The social and cultural implication of science was not dealt with in the module in its present form but the potential for incorporating this component of scientific literacy exists. The Plan of the module is depicted in Table I. Table II represents a summary of the contents of the module, listing the objectives, rationales and basic concepts covered in the learning exercises. Through systematic use of the module students should develop critical mindedness and objectivity as they

1. look for inconsistencies in statements and conclusions;
2. consult a number of authorities when seeking information;
3. look for empirical evidence to support or contradict explanations;
4. ask questions such as what, where, why, when and how;
5. Challenge the validity of unsupported statements.

Student Response to the Scientific Literacy Module

The module was used by 160 nonscience major students over a four year period. Informal assessments of the module were conducted on three different groups of students. Group 1 used the module for all non-text book readings and audiovisuals and were asked to respond to the Scientific Literacy Module Questionaire. A tally of the results is presented in Table III. The responses indicate the students think as a result of using the module they learned science facts, and concepts, realized the pitfalls of making unsubstantiated assumptions, know that conclusions must be based on adequate, data and better understand the importance of presenting more than one side of a controversial issue. Group 2 used the module for all non-textbook readings and audiovisuals for the semester and were asked to evaluate the module the following semester. Table IV is a summary of selected student comments to specific question.

A prevalent focus was the process of systematically looking at alternatives, analyzing facts and sources of the articles, and guiding decision making. An important benefit of using the module seems to be its long term effect in aiding the student with analyzing complex issues such as energy both during the course proper and the following semester.

Group 3 was given the module but was not required to use it while working on an energy issue project of their choice. Student opinion on the value of the module as a learning experience focused on developing objectivity, looking for empirical evidence, and consulting a number of authorities, while dealing with the literature for their study.

Conclusion

Science affects almost every aspect of our lives today, and we can expect that domination to be even greater in the future. It is, therefore, in the common interest for the public to gain a better understanding of science and its application. The scientifically literate layman is stimulated, rather than confused, by contradictory scientific opinions. The challenge to the science educator is to reach the nonscientist so that he can make informed decisions on the impact of science and technology on his life. The Scientific Literacy Module can be used by science educators to provide a realistic, useful and relevant educational experience. It provides the student with a tool to systematically evaluate such complex issues as the energy problem. It can develop scientific literacy to the point of enabling the student to make intelligent decisions about personal and societal energy matters.

[1] National Science Foundation and Department of Education report to the President of the United States. "State of Science and Engineering Education in the United States, Part I: Science and Technology for all", National Science Foundation, Washington, D.C., (1980).

[2] K.F. Weaver, National Geographic, February, 18 (1981).

[3] G.T. O'Hearn, Science Education, 60,103 (1976).

[4] G.T. O'Hearn, 106

[5] This is to acknowledge the Scientific Literacy Module was designed according to the format developed by J. Bruce Francis, Ph.D. Associate Professor of Higher Education at the State University of New York at Buffalo, for individualized instruction

Table I

PLAN OF THE MODULE

The module consists of a series of steps to be followed in sequence. The steps include:

A. A series of *objectives* expressed in terms of competence or capability. These represent the components of the process of critical evaluation of the literature.
B. A *rationale* showing how attainment of the objective contributes to good evaluation.
C. A set of *readings.*
D. A set of *learning exercises* which will both facilitate and direct your learning and will serve as a form of posttest to assess how well you have mastered the objective. The exercises are designed to help you develop the skill of critically evaluating the literature. Only when you have sucessfully completed these exercises and are confident of your understanding should you move to the next objective.

Table II

SUMMARY OF THE CONTENTS OF THE SCIENTIFIC LITERACY MODULE[5]

Upon completion of the module the student will be able to:

Objective #1

To discern the hypothesis of the investigation.

Rationale #1

The author of an article usually includes in the introduction a statement of the problem and its background. The author or researcher states the purpose of the investigation, that is, the specific question(s) he or she is trying to answer. He or she also describes everything that has been found out concerning the problem.

Learning Exercise #1

Questions relating to:

Hypothesis

-importance of the problem
-clear statements of the hyopthesis
-assumptions

Objective #2

To describe how the investigation was done

Rationale #2

The methods of data collection should be described clearly and in enough detail to that you can follow exactly what the investigator did. These methods should be appropriate for the question investigated.

Learning Exercise #2
Question relating to:
Methods
-description and appropriateness of methods
-source of data; people's opinions (survey), observations and/or measurements, informations from other sources
-information reliability, bias, and number of observations

Objective #3

To characterize what was found as a result of the investigation.

Rationale #3

The *results* of a study present the data collected for inspection by the reader. The results should be presented in a straightforward manner, with no conclusions or value judgement as to what data might mean.

Learning Exercise #3

Questions relating to:
Results
- data: clarity, form amount

Objective #4

To evaluate how the data were interpreted.

Rationale #4

While *interpreting data* the investigator explains what he thinks the results mean. He or she describes any patterns that emerged, any relationships that seem to have been meaningful. The investigator makes conclusions about the meaning of the data and explains why he or she has reached those conclusions. In effect, the investigator is defending his or her point of view.

Learning Exercise #4

Question relating to:
Data interpretation
- support of conclusions by data
- possible alternate interpretations of data
- use of different sources of information
- importance of the findings
- additional questions raised by the study.

Table III

TALLY OF: SCIENTIFIC LITERACY MODULE QUESTIONNAIRE

5 I strongly agree
4 I agree
3 I am uncertain
2 I disagree
1 I strongly disagree

After you have carefully read a statement, decide whether or not you agree withit. Select the number from the above scale which indicates your degree of agreement of disagreement with each of the statements below.

The following questions relate to the Scientific Literacy Module. as a result of using the module:

*4.375	1.	I learned a certain amount of science facts and concepts.
4.541	2.	I have improved my ability to critically evaluate material.
3.666	3.	I better understand how experimentation should be done.
4.291	4.	I realize the pitfalls of making unsubstantiated assumptions.
4.583	5.	I better understand the importance of presenting more than one side of a controversial issue.
4.708	6.	I know that conclusions must be based on adequate data.
4.250	7.	I feel I now use ability to critically evaluate in other areas than biology reading assignments.
4.500	8.	The Scientific Literacy Module was well orgainzed.
3.500	9.	I feel the Scientific Literacy Module could be used in disciplines other than science.
4.25	10.	The module educated me to work independently.

*Average scores for n = 24.

Table IV

SUMMARY OF STUDENT COMMENTS ON USE OF THE SCIENTIFIC LITERACY MODULE
HOW DID THE MODULE AID YOU IN CRITIQUING ARTICLES?

- "By using the module one can more easily see there could be bias in the article, and know where the credibility lies."
- "It helped me know exctly what I was looking for and helped me judge things in the right light."
- "It helped in looking for questions in articles that I had previously not loked for. Such things, as actual data or writer's opinions of articles and were experiments used or not to substantiate the data."
- "It helped me to analyze the facts and the sources of the article. I learned to judge how good an article was or how bad."
- "It established an orgainzed, systematic procedure for evaluating and presenting the material."
- "The module was a base to starting a critique of the articles. It was a help in understanding what to look for the suspect in articles."

Did the module help you to look at both sides of an issue?

- "The module helped you to not only look at both sides of the issue but also to consider the possibilities and positions for an issue".
- "Yes it certainly does! It provides a systematic method to look at both the long term and short term negative and positive effects."
- "I'm not sure that it helped in any way to see the opposing side of a problem. I think it helped to be objective when critiquing however." (many students just answered yes)

We spent some time on the complex energy problem. Did the module help you to evaluate the energy issue in your class readings or your readings since? If so, how?

- "Yes, because it helped me to look at the different alterntives of energy and enabled me to make a choice of good possible energy choices for future consumption."
- "Yes, by establishing realistic qualifications such as cost, time development, and health implication, etc. of alternate energy sources. Especially informative was the restricted application of solar energy in Wisconsin's climate."
- "Yes, the module showed othe facts about different types of energy. They were explained in detail. The module looked at a large amount of pro's and con's for any type of energy.
- "Yes, it orientates the mind to think systematically. One looks at both sides of the isssue. Noting from the source as to which side the article is on. One gets a more comprehensive grasp of the issue.

27.5

ALTERNATIVE ENERGY AND ELECTRONICS

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Abstract
This paper describes a new course given to entering freshmen electronics technology majors in the standard and advanced courses at Wentworth Institute of Technology in Boston. The purpose of the course is to introduce the students to alternative energy systems (solar thermal, solar photovoltaics, wind biomass and ocean thermal) and the ways in which electronics are used in these systems. This paper presents the course outline, a description of the types of problems the students were required to solve, and some examples of the systems used to illustrate the role of electronics in alternative energy systems. A brief description of classroom demonstrations and student projects is also included.

I. Introduction
A new course in electronic applications to the alternative energy field was developed and taught at Wentworth Institute of Technology in Boston, Massachusetts in the Fall and Spring of 1980-81. The purpose of the course is to give first year electronic engineering students an overview of the specialized electronics courses they will be taking over their two or four year course of study at Wentworth. Another objective of the course is to give the students some fundamental and systems type information about alternative energy systems. The rationale for using alternative energy systems, such as solar thermal, solar photovoltaics, wind and biomass,as a vehicle for teaching electronics is that these systems appear to represent a large market in the future for electronic systems and the best preparation for people who will be troubleshooting part of a system is understanding how the entire system works. The basic difference between this course and a physics course is that the physics is used as a tool to explain the systems studied. The course was developed from a continuing education course on energy alternatives taught at the Massachusetts Institute of Technology's Lowell Institute School in the Fall of 1979.

II. Course Outline
The course consists of the eleven units listed below:

Energy and Power
Solar Geometry
Solar Radiation
Energy Storage and Transfer
Heating Ventilation and Air Conditioning
Solar Thermal Systems
Wind and Hydroelectric Systems
Biomass
Ocean and Geothermal Systems
Nuclear Energy

The first five units represent the fundamentals necessary for the study and understanding fo the systems discussed in the last six units. The application of electronics is stressed in each of the eleven units, even those representing fundamentals. The course, as it was taught the first year, is a two-credit course, meeting twice a week for fifteen weeks. Classroom demonstration of electronic instrumentation used in the various systems is an integral part of the course. The demonstrations could be made into laboratory experiments for an expanded course. A student project was a part of the course as it was taught. The course could also be taught to mechanical power or other nonelectronic majors as an electronics course with applications from the non-electronic major area, since many of the systems studied have mechanical sub-systems. The following sections describe the scope of each of the units in the course outline along with a brief description of the demonstrations, student projects and homework problems.

A. Energy and Power
The unit introduces the concepts of energy and power by examples and by emphasizing the various units associated with energy and power. In the units on systems, it is important for the student to be able to relate Kilowatts per square meter and British Thermal Units (BTU) per hour per square foot, since specification sheets usually deal in a variety of units. The concept of energy equivalent for fuels is introduced to explain the method for comparing costs of wood, oil, gas and electric heating systems. Some examples of problems for this unit are presented in Fig. I

B. Solar Geometry
This unit defines the terms and geometry necessary for understanding the motion of the sun and its effect on the performance of the solar radiation systems studied in later units. Electronics used in sun tracking are described, and the concepts of open loop and closed loop tracking are presented. Typical problems for this unit shown in Fig. 2. The advanced students designed and built sundials as a project contest. The winning sundial was a pin hole sundial with readout on a cone under the pin hole.

C. Solar Radiation
The relations between radiant energy and temperature and the greenhouse effect are presented in this unit. Instrumentation for measuring sunlight power and temperature and the role of electronics in data collection and processing are presented. Typical problems for this section are shown in Fig. 3. Demonstrations of radiometric equipment for measuring sunlight intensity (pyranometer) is presented together with data logging equipment.

D. Energy Storage and Transfer
In addition to describing heat transfer and storage in air, water and rock, the storage of heat by phase-change materials (PCM) is presented. Electrical energy storage in batteries and mechanical energy storage in flywheels is described as well. Heat pump operation is covered and the application of heat pipes as heat sinks in electronic systems is presented. Some problems for this unit are shown in Fig. 4. Demonstration of battery state of charge by current measurement is presented in this unit.

E. Heating Ventilation and Air Conditioning
HVAC, as the industry is known in the United States, is an area where electronics is growing each year. Many new energy saving electronic devices, such as set-back thermostats and boiler temperature control based on outside air temperature, appear each year. In this section, the elements of heat loss calculation for structures, including both convective (infiltration) and conductive heat loss, are stressed. The relation between heating degree days and design temperature is presented. Heat loss problems for electronic chassis is a natural extension of building heat loss. Some typical problems are shown in Fig. 5. The measurement of temperature by thermistors and thermocouples is presented as a classroom demonstration for this unit.

F. Solar Thermal Systems
This unit begins the study of systems. The study of solar thermal systems uses the principles studied in all the previous units. Passive and active systems, as well as combinations of active and passive techniques, is presented. Various electronic differential thermostats are described and demonstrated. Fig. 6 shows problems for this unit.

G. Solar Potovoltaic Systems
Solar electric systems hold the promise of setting households independent of electric utilities in the future, or reducing the cost of electric energy from a utility. One of te projects given students the second time the course was taught was to design and document a solar cell system. The application was left to the student and resulted in a wide range of applications from very expensive appliance applications to some relatively inexpensive alarm systems. Power conditioning, battery charging and combined thermal and PV systems as well as utility interactive solar PV systems are presented. Problems associated with this unit are shown in Fig. 7. Measurement of a solar panel current-voltage characteristic is performed as a demonstration for this unit.

H. Wind and Hydroelectric Systems
Vertical and Horizontal axis windmills are described and the power conditioning problems associated with windmills is presented. The use of hydroelectric plants for sharing utility peak power requirements is discussed. Fig. 8 presents sample problems for this unit. Measurement of rotational speed using an LED and photodiode is demonstrated in class.

I. Biomass
Fuel is one way of providing storage of energy. Biomass in the form of wood, methane, and alcohol represents renewable fuel in solid, gas and liquid form. The use of electronic temperature measurement and control in the generation and use of these fuels in described. Fig. 9 shows examples of problems for this unit.

J. Ocean and Geothermal Systems
As with wind and hydroelectric systems, ocean and geothermal systems have been around for a long time. It is the application of new electronic control and measurement which raises the hope for these systems to become competitive with petroleum-based systems. This is the view from the vantage point of an electronics. Fig. 10 presents some problems for this unit.

K. Nuclear Energy
The difference between nuclear fission and fusion systems is presented along with a description of how present day nuclear plants generate electricity.

III. Conclusion
In addition to the classroom demonstrations and the two student projects described in the previous section, slides of actual systems are used. A random sampling of the students who took the course indicated an overall rating of "good" for the course on a scale of "good", "average", and "weak". Course organization was rated "good" by the students A breakdown of the ratings from the 104 responses received was: 68 good, 32 average, and 4 weak.

IV. Acknowledgements
The author wishes to thank Professor Bruce Wedlock of the Lowell Institute School of M.I.T. for the opportunity to develop and teach the precursor to the course described in this paper. Also acknowledged are Professor Alexander Avtigis of Wentworth Institute of

Technology, who initiated this course, and Professor Robert Coughlin who taught one of the three sections of students and who contributed greatly to the material in the course. The author also wishes to acknowledge the SOLAREX and SPIRE corporations for support in the Solar Photovoltaic area and to the M.I.T. Lincoln Laboratory for the opportunity to stay current in the solar cell field.

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Energy and Power Problems
The mileage of a car with a gasoline engine is expressed as 30 miles/gallon. Express the mileage in miles/joule; miles/BTU, miles/Kw-hr.

If a fuel with an energy equivalent of 145 million joule/gallons is used in the problem above, what will new mileage figure be in miles/gallon?

Solar Geometry Problems
Compute the amount of overhang required to shadow a glass door 8 feet high, if the overhang is 10 feet from the ground. The shadowing is required for a noon elevation angle of 71 degrees.

When it is 11:00 a.m. in Greenwich, England, what is the time at the center of the Eastern Standard Time Zone?

Solar Radiation Problems
How large an area is required to capture 0.5 horsepower at an air mass of 1.2?

At what wavelength is the radiation of a 2900 degree Kelvin block body a maximum?

Energy Storage and Transfer Problems
Calculate the thermal resistivity (R value) for the following thicknesses of fiberglass insulation: 3 inch, 6 inch, and 12 inch.

A tank 6 feet in diameter and 5 feet long is used to store 1057 gallons of water at 120 degrees Farenheit. The R value of the tank is 11. How much heat will be lost if the surrounding temperature is 65 degrees Farenheit?

HVAC Problems
How many Kilowatt-hours are required to replace 4 amps of current drawn from a 12 volt battery for 2 hours? (Assume 100 percent charging eficiency.)

Solar Thermal System Problems
How many BTU are stored in 100 gallons of water raised to a temperature 50 degrees Farenheit above room temperture?

What is the principal difference between a collector designed for heating a swimming pool and one designed to provide domestic hot water?

What is the chief drawback of a liquid thermosyphon system vs. a system with a pump?

Solar Photovoltaic Problems
Which way will the open circuit voltage of a silicon solar cell shift (to higher or lower voltage) when temperature increases?

Which solar cell should produce more power - cell with a 4 inch diameter or a 2 inch diameter? Which cell hsa higher voltage under the same load?

Wind Problems
If a manufacturer describes the output of a windmill at 12 mph as 2 kw., how much power would you expect at 6 mph?

Which type of windmill is not sensitive to wind direction: a vertical axis or horizontal axis mill?

Biomass Problems
A methane digester consists of 7 - 55 gallon oil drums. If it produces 39 cubic feet of gas per day, how much energy does it produce?

If 140 proof alchol can be burned in a modified oil furnace, what percent of the fuel is water?

Ocean and Geothermal Problems

A geyser produces geothermal steam at 170C. What is the carnot efficiency?

A proposal to drill through 22,000 feet of granite at Conway, New Hampshire to obtain 4000F steam is made. What is the carnot efficiency if the surface generator is working at 212F?

27.6

UNIVERSITY GENERAL EDUCATION COURSE ON ENERGY

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In the Autumn Term, 1980-81, a revision was made in the 3 sem. hr. general education course, "NS II: Foundations and concepts of Physics", offered at International Christian University. The basic goals of this revised NS II course — one intended primarily for non-science major students — have remained the same as in the past: as stated in the course description, "...to examine the fundamental relationship between theoretical and empirical knowldge in the physical sciences through the study of selected topics in physics...".

As its focus for the "selected topics", the older form of NS II used the theme of the establishment of classical and relativistic mechanics. The student was asked to read excerpts from Aristotle, Galileo and Newton concerning the establishment of classical mechanics, as well as excerpts from Einstein-Infeld's "The Evolution of Physics" (particularly Part III dealing with "Field And Relativity") concerning the fundamental revisions introduced by Einstein. Throughout, emphasis was laid on the relationship between physical theory and experimental findings in "sorting out" and improving physical concepts; and the readings were examined from this general "tactics and strategy of science" point of view.

In its revised format, as stated in the course outline given to students, "..the course examines the growth of empirical knowledge and the expanding theoretical understandings connected with 'energy'. The history and root ideas involved in the mechanical and thermal origins of the energy concept, as well as their interconnections, are examined, aided by the study of 'landmark papers' such as those of Newton, Leibniz, Rumford, Joule, Mayer and others. The extension of the energy concept to other fields of physics, as well as to engineering and modern technology, is also outlined. In the latter part of the course, attention is given to contemporary concerns with the availability and a renewability of energy 'sources' in present-day society."

From the above, it is doubtless clear how the "Readings On Energy" are intended to be used. It is hoped that by studying the Readings, the student will develop a greater awareness and appreciation for "science as process" — an interplay of human creative activities in both theoretical and experimental areas — and also a greater understanding and interest in "energy" and contemporary energy questions. Building upon these readings, the lectures are designed to aid the student in generalizing his/her understandings of the basics of energy acquired through the study of the "landmark papers", and to present applications of the energy concept to present day problems.

It is considered that there are several advantages in having non-specialist students in a general education course in science follow an "original papers" reading approach. First of all, through the examination of such papers, the student is more apt to perceive the persistent, yet often groping, quest for scientific knowledge and understanding at the initial stages of an inquiry into a given field of investigation, before most of the confused and personal elements involved have receeded, and a more precise and formal format has emerged: in this more formal stage, technical operations and terminology have become more precise, and hence are further removed from the non-specialist's experience, language and appreciation.

From the above, a second advantage of using "original papers" may be seen: namely, the non-specialist student may be better able to understand the context, content and scientific meaning of the specific topics examined if these are taken from an early stage of conceptualization, more apt to be free of technical elaboration than a later, advanced state of development. Indeed, improved understanding of this sort, *on the part and by the initiative of the student*, is more to be valued educationally than any amount of detailed "replication" of factual material presented in the course by the instructor; and such an educational objective is by no means to be limited to the non-specialist student.

The topics covered in the "landmark paper"readings may be seen from the following listing —

Mechanics —	
NEWTON: Laws of Motion	(4 pp.)
LEIGNIZ: Conservation of Vis Viva (Kinetic Energy)	(8 pp.)
Heat —	
BLACK: Thermal Equilibrium; Heat Capacity	(2 pp.)
LAVOISIER: "Caloric" Theory of Heat	(2 pp.)
Mechanics, Heat and Energy —	
RUMFORD: Heat In Relation To Work	(5 pp.)
DAVY: Heat As Vibration	(1 p.)
JOULE: Mechanical Equivalent of Heat	(2 pp.)
MAYER: Conservation of Energy (Mechanical, Thermal, Etc.)	(2 pp.)
Empirical Gas Laws —	
BOYLE: Pressure-Volumne Relationships in Air	(3 pp.)
GAY-LUSSAC: Volume Changes of Gases Due To Temperature Changes	(3 pp.)
Thermodynamics —	
CARNOT: The Idealized "Heat Engine"	(3 pp.)
CLAUSIUS: Second Law of Thermodynamics; Entropy	(5 pp.)
KELVIN: Second Law of Thermodynamics; Absolute Temperature	(3 pp.)

In addition to the "Readings" listed above, students in NS II were provided with a total of thirteen "Supplementary Notes". These were intended to serve either of two general functions:

a) To summarize (verbally and algebraically), or to illustrate more concretely (usually by means of graphs or numerical illustrations), the ideas presented in the "Readings".

b) To present new material not treated in the "Readings". Examples —

- (After Mayer's paper) Forms of Energy And Their Inter-convertibility; Conservation of Energy And The First Law of Thermodynamics
- Efforts at Constructing "Perpetual Motion" Devices
- (After Boyle's and Gay-Lussac's papers) The "Gas Cylinder Device" and The "Empirical Gas Equation"
- (After Carnot's paper) Application of the "Gas Cylinder Device" to the Carnot Cycle; Thermal Efficiency of the Carnot Cycle (in terms of Heat Input, Q_1, and Heat Exhaust, Q_2)

- (After Clausius' paper) Thermal Efficiency of the Carnot Engine (in terms of "Thermal Reservoir" Temperature, T_1, and "Thermal Receiver" Temperature, T_2), using the concept of "Entropy": Numerical Illustrations.

- Efficiencies of Several Practical Engines:
  a) Steam Engine (b) Steam Turbine
  c) Internal Combustion Engines—
  i) Gasoline Engine (ii) Diesel Engine

- The "Reversed Carnot Engine": The Refrigerator
- The "Heat Pump"
- The "Second Law of Termodynamics"
- "Total Energy Costs" of Heating/Cooling A House:
Process Energy Resources: "Energy Capital" and "Energy Income"
- "Renewable Energy Sources": Solar Energy, espec. "Solar-Thermal" and "Solar-Electrical"
- Three Types Of Growth:
  a) "Linear Growth" ("Doubling-Time" becomes longer and longer)
  b) "Exponential Growth" ("Doubling-Time constant)
  c) "Accelerative Growth" (Doubling-Time becomes shorter and shorter)
  - World Energy Consumption: Present Values and Growth Rate

Experience with the revised format of NS II, in which the development and application of the energy concept is treated as outlined above, has been definitely encouraging. Student interest and effort, as well as achievement, have been high, despite the appreciable amount of reading and attention to new terminology and concepts required of them. There was some indication — to be explored further in subsequent offerings of the course — that students found the fundamental approach to energy followed in this course to be meaningful in considering comtemporary energy questions and problems.

27.7

ENERGY: FOCAL TOPIC FOR AN INTERDISCIPLINARY CORE SCIENCE COURSE*

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Abstract
An interdisciplinary science course, team-taught by a biologist, a chemist, and a physicist, has been developed at Curry College as part of a core liberal arts curriculum. Emphasis is placed on *how* the sciences achieve an understanding of the natural world. Methodologies, concepts, and attitudes are examined in the context of a few major focal topics germane to all the sciences. Of these, energy is the most extensively treated. Text modules have been specially developed to reflect the course's unique treatment and perspective.

Energy as a conceptual construct (as opposed to a direct percept) having broad explanatory power is developed from its intuitive roots in ordinary experience to formalization as a measurable quantity. Considered first in macroscopic, observble, everyday situations, the energy idea becomes increasingly powerful when applied to microscopic models in simple chemical systems, and then to the more complex chemical systems found in living organisms.

The predicative power of explanatory structures makes technologies possible. We focus on energy technologies, examining modes of energy production and delivery and their consequences in terms of prlciples developed previously. Conceptual tools developed to understand the natural world are then applied to the societal problem of energy decision-making.

Text
At Curry College we have developed an interdisciplinary science course, team-taught by a biologist, a chemist, and a physicist, as part of a central liberal arts curriculum required of all students. Emphasis is placed on *how* the sciences achieve an understanding of their subject matter. Methodologies, concepts, attitudes and consequences for society are examined in the context of a few major focal topics, of which energy is the most extensively treated.

In this context, energy is considered both as a paradigm of a conceptual construct and as the focus of one of the critical issues of our time. On the one hand, we raise the question of how an abstract concept such as energy arises out of the sensory experience from which all science begins. What intuitive notions, and what needs, lead to the energy concept? On the other hand, we deal with the notion of energy as a commodity, one that can be in abundant or short supply, and one to which one can attach a price, as electric power companies do. The latter concern requires that energy be defined quantitatively, and this practical need, which is ultimately the need to measure, determines the form that the abstract energy concept must take. From this vantage point, it becomes evident to students that questions of physics and economics are intimately related in considerations bearing on the energy crisis. In the context of a core course for a liberal arts curriculum, this also reinforces the notion that the style of thinking represented by the sciences is extensible to other areas, and is applicable as well, for example, to the societal and economic questions raised by the energy crisis.

Our treatment of energy is in some ways novel, and is presented fully in a series of text modules we have developed and are continuing to develop with NSF support. The modules cover other aspects of the course as well. A fuller overall discussion of the course is to be published elsewhere.[1] Detailed syllabi are available from the author upon request. We begin by exploring the intuitive roots of the energy concept, asking students (especially those without physics background) what associations they make with the words *energy* and *energetic*. Intuition, we recognize here, is not free of cultural context, which generally includes an ill-defined connection between energy and technology. In proceeding on this basis, our intent is not to reconstruct the history of the energy idea with any obligation to historical accuracy. Historians of physics have recognized that the formal events of physics, *e.g.* the published results, do not typically reveal the process of development of ideas.[2] Even in traditional physics teaching, where there is a strong concern for the historical development of ideas, we teach Newtonian physics as though it were pre-cast in mathematical algorithms rather than as the first enduring success of a continuous historical development from Artistolelian physics. Yet, as Champagne[3] and her colleagues pointed out, the intuitive thinking of many of our students remains essentially Aristotelian (for example, no motion in the absence of a force), and for them the Newtonian scheme is an unmotivated abstraction. For those of our students (and they are the majority) who resist unmotivated abstractions, a reasonably continuous development from the student's own intuitive notions and cultural biases can serve as an underlying model which makes the abstraction more acceptable. If we are coming dangerously close to apocryphal history here, we are nevertheless avoiding involving students in the morass of historical details surrounding the development of the energy idea in the nineteenth century, details for which the student would have to substitute a nineteenth century worldview for his own cultural biases to understand fully.

Class discussions quickly establish that students have some prior assocation of the terms *energy* and *energetic* with heat, with motion, and with utility, which can evolve into a more formalized notion of work. They are then asked to consider a sequence of situtations involving energy input, storage, and output. Three systems, a weight-driven pendulum clock, a dry cell connected to a light bulb, and a hydroelectric plant generating electricity for the operation of an electric fan, provide examples of most of the major aspects of energy that we seek to cover. Students note in qualitative terms the transformations that occur, though they don't yet readily identify these as energy transformations. With regard to utility, they associate useful work done with energy expended. They recognize that stored energy can be associated with position (*e.g.* the height of the waterfall or of the clock weight) and that the position is achieved by separating objects bound together by an attractive force (such as the gravitational force between the clock weight and the earth). Thus, by an input of work a system gains potential energy which can, at a later stage, be actuated as kinetic energy, *i.e.* energy of motion.

The students' first encounter with potential and kinetic energy is thus qualitative and situational. In this treatment, a groundwork is also established for later considerations. The notion of increasing potential energy by doing work against attractive forces internal to a system is later extended to chemical potential energies and binding forces. The stepwise release of energy with each tick of the pendulum clock later provides a suitable model with which to compare the energy release in respiration. The electric bulb reminds students that not all energy can readily be categorized as potential or kinetic, but that radiated energy must also be considered. This we do later and at length.

After considering an additional set of situations in which students determine on intuitive grounds whether or not work is being done, we introduce the standard Newtonian quantitative definition, emphasizing the consistency of the quantitative statement with prior qualitative statements. The fact that if *either* force *or* distance is zero then no useful work is done provides a rationale for defining work as a product.

Considering work done by an unopposed force and by a force acting against gravitation then gives us the standard derivations of quantitative expressions for kinetic and gravitational potential energies. But the resulting equations are treated as mathematical statements which, like the work definition, must be entirely consistent with prior qualitative statements. For example, in the equation

$$mgh_i - mgh_f = \frac{1}{2} mv^2 - \frac{1}{2}mv_i^2,$$

which occurs after we have identified $\frac{1}{2} mv^2$ with kinetic energy, students see that the decrease in a quantity dependent on position (the height *h*) gives rise to an increase in kinetic energy. That this quantity thus meets the criteria established previously for potential energy in qualitative terms makes plausible the identification of the quantity *mgh* with potential energy. This approach of talking through equations is a revelation to many of our students who have seen equations only as puzzles to be solved for numerical answers. They begin to see equations as algorithms for real-world situations, in which the symbols represent measurable quantities, so that the statement must be cast in quantitative terms. Again we are promoting a mind-set which is extensible beyond physics.

As it is extended from the macroscopic to the microscopic realm, the energy concept is also extended across disciplines. After suitable development of atomic models, the notion of energy input or work against internal attractive forces is applied to these microscopic systems. Thus, energy input is needed to break chemical bonds by overcoming the forces that hold chemical species together and energy is released as the species come back together again. The macroscopic mechanical analogy makes an exothermic reaction understandable in these terms, and an endothermic reaction is similarly understood. The same reasoning is extended by our biologist to the more complex endothermic process of photosynthesis and the more complex exothermic process of respiration. Here, as elsewhere in the course, our procedure is for the physicist to develop a concept using readily visualized macroscopic systems. The chemist then extends the concept to simple microscopic systems, and the biologist to the more complex microscopic systems found in living organisms. Similarly, when entropy is discussed, the need for an energy input to create or sustain order might first be considered in a macroscopic situation such as the maintenance and repair required by an old building. The chemist would then extend the notion, say, to the unmixing of fast and slow molecules by a refrigerator. The biologist would then deal with the continued input of energy required to maintain the high degree of order in the complex molecules, such as proteins and nucleic acids, that characterize life.

The macroscopic-to-microscopic transition is also made for radiated energy. A full rationale for a wave lies beyond the scope of the course. However, the unequal transparency of a pane of glass or of an atmosphere to different wavelengths proves adequate to account for the heating that occurs in a more-or-less macroscopic situation such as the greenhouse effect. For the photoelectric effect, on the other hand, the wave picture fails and students see that a photon picture is necessary in order to understand the input and output of energy on an atomic or subatomic scale. Again the idea is extended to the more complex microscopic systems found in living things, in this case pigment molecules. Students see that the absorption of photons by the electrons of highly complex molecules such as chlorophyll, in which the allowable energy jumps match the photons available from the sun, initiates the photosynthetic process by which most of the energy used by life on earth (humans included) is captured. They also are made aware that this captured energy, like all other radiated energy received from the sun, ultimately gets radiated back out into space, and that our concern with solar energy is keeping it around long enough to use it.

When we turn from energy as a conceptual construct with broad explanatory power to the development of a technology based on the understanding so gained, we see that the inclusion of biology in an area traditionally seen as the preview of the physical sciences has not been gratuitous. The conceptual underpinnings of our present energy technologies derive principally from physics and chemistry; our treatment of these technologies is tied to principles the students have already considered, and is relatively conventional. But this "grey technology", as Freeman Dyson[4] terms it, may in the future be challenged by a so-called "green technology" as our understanding and control of biological processes on a molecular scale grows.

Moreover, as regards the current global energy predicament, in which the consideration of energy as a commodity is important, it is necessary *inter alia* to consider the competition for energy resources between our internal and external needs. The author is billed monthly by Boston Edision for an amount of energy approximately equal to the caloric intake of his family for the same period. On a more global scale, the agriculture necessary to provide for that caloric intake has become increasingly energy-intensive, while arable land continues to get paved over by a species seeking living space for its exponentially growing population. A contribution from biology is necessary in order for the students to see these issues in all their complexity.

Students emerge with a view of a global store of energy having, in the terms to which they have become accustomed, multiple inputs and outputs. By this stage they have had considerable exposure to the idea that models of the natural world are adjudged valid insofar as they can predict outcomes accurately. Modeling a global energy system at any level requires a suitable selection of quantitative data and an array of simplifying assumptions. Students see this done for a smaller but comparable system, the U.S. energy supply. At the end of the course, they get to test their own strategies for meeting U.S. energy needs on an energy-use synthesizer developed for the U.S. Department of Energy.[5] Their strategies should by now be informed by some depth of understanding, and hopefully also reflect an awareness that systems do not exist in isolation and that America's energy needs should not be so considered.

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5. available with speaker in Boston area from Mass. Voice of Energy, MIT Student Chapter, 138 Albany St., NW12-134, Cambridge, MA. 02139. For regional availability elsewhere, contact the U.S. Dept. of Energy

27.8

CREATIVE DELIVERY PATTERNS FOR AN ENERGY COURSE

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Abstract
An energy course, entitled: Energy Resources and Conservation, has been offered at Prince George's Community College for the past six (6) semesters. This three credit physical science course was originally developed for delivery by the conventional lecture-discussion format over a 15 week semester. However, it has been modified so as to be capable of delivery in a 5 week summer session; as a course by newspaper utilizing resource materials prepared by the University of California, San Diego and 15 weekly newspaper articles published in a local newspaper; and, as a course taught over three weekends. The latter three formats have shown particular appeal to an older and more diversified audience than that which normally registers for the course taught during the regular semester.

The course, which fulfills a three credit physical science requiremen for students who wish to transfer to a university, includes a discussion of energy transformations, energy units, conventional energy sources, alternate energy sources, and potential new energy sources. Field trips to fossil fuel power plants, energy research laboratories, solar buildings, and a nuclear power plant, have been included. The interrelationship between energy and the social, economic, and political arenas is woven into the course.

SESSION 28: ECONOMICS, ETHICS, AND THEORY

28.1

ETHICS IN THE CLASSROOM - MORALITY AND THE LAWS OF THERMODYNAMICS

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Modern physical science may be said to have begun in the time of Galileo. Prior to this time, the "why" of a phenomena was seldom separated from the "how", e.g., heavy objects fell because their "natural place" was at the center of the earth-which was the center of the universe. Descriptions and explanations of physical phenomena had to fit into a grander scheme which included man's place in the universe as well as his relation to God and his fellow man. Challeges to accepted physical ideas were strongly coupled to challenges to the normative ethical-moral precepts which "followed" from the accepted religious and political ideas and were therefore strongly suppressed.

We all know about the burning at the stake, by the medieval churchstate, of Bruno who dared to suggest that our world was not the only world in the universe. More recently, we have heard about the repression of Lysenko's opponents, those whose scientific ideas in genetics interfered with the political-philosophical views of biological perfectibility held by a modern ruling class. We may explain the apparent failure of European man to observe and record the appearance of the Crab-nebula supernova in A.D. 1054, even though it was apparent to Chinese and American Indian observers[1], by noting that such an observation implies the non-immutability of the heavens, contrary to the commonly (European) accepted scriptural cosmology. As a cap to the pre-scientific view we have Galileo's contemporaries refusing to use new instruments for fear of bringing themselves into conflict with established beliefs: "...what would you say of the learned here, who, replete with the pertinacity of the asp, have steadfastly refused to cast a glance through the telescope?"[2]

As a reaction to the self-imposed blinders of political-religious views, modern science has striven to keep religion and politics - and their presumed ethical correlates - out of its development and teaching. Religion and ethics were to be kept at home or in the church and out of the secular classroom, e.g. organic chemistry flourished because its developers were *not* concerned with whether it would be used for medicine or poison gas but were just concerned with how "amoral" carbon atoms combined to form molecules and how these molecules constituted and influenced living and non-living systems. In spite of the attempts by some religious fundementalists to return to the pre-Galilean era, to link purpose and ethical precepts to supposedly scientific ideas, e.g., "scientific creationism", most scientists (and non-scientists who respect the intellectual climate of science and/or the important benefits its practical applications have brought to humanity) are aware of the possibility of, and would be hostile to, the restoring of blinders to science, to consciously allowing political or religious of blinders to science, to consciously allowing political or religious outlooks to control or influence the kinds of scientific questions which may be asked or the kinds of answers which may be pursued.

But there is a reverse influence - the influence of established science on moral outlooks - which is often ignored by many scientists and teachers. Yet, accepted scientific beliefs can have a *major* impact upon private and social morality; different scientific laws lead to and support very different moral outlooks. To ignore these "feed backs" is to confine science to an ivy tower, cut off from the major concerns of the vast part of the population who are neither technologists nor scientists. For example, a society whose scientific beliefs about energy was limited to the First Law of Thermodynamics could be selfish and filthy, polluting and wasteful of energy and resources.

This follows because the First Law states that energy, "the ability to do work", can be neither created nor destroyed - that "perpetual motion of the first kind", in which an isolated system ends up with more energy than it started with, is forbidden. Thus, certain kinds of "behavior" are prohibited. For example, we can't go to an isolated place having little energy, such as a distant minor planetoid, and expect to do lots of separative work there, such as extensive mining and removal of minerals; each export implies an increase in the energy of the system - the separation or binding energy. However, nothing in this Law prevents energy from being reused over and over again, indefinitely. "Perpetual motion of the second kind", in which energy transformations occur without changing the amount of useful energy in an isolated system, is not forbidden. If we stay within a system, we can do an indefinite amount of work; since energy could be reused indefinitely, it would not matter if the initial supply of energy were finite. It would further follow that there are no restrictions upon the use of material resources since, by doing enough work, materials can be recycled indefinitely and pollution reduced to any desirable level[3]. A simple, pleasant, moral implication can be drawn from the assumption that the First law is the sole determinant of energy use: Whatever we do, we will not deprive our posterity of anything, as long as we stay here on earth and don't rocket away with lots of energy.

When the Second Law of Thermodynamics is added to our system of beliefs, quite different kinds of behavior are called for. This fundamental law can be expressed in several different but equivalent ways: a) Heat flows naturally from hot bodies to cold bodies. b) Heat will not move form a cold body to a hotter body (refrigeration) without an energy input. c) It is impossible for a system (a heat engine) to take in heat at a high temperature and perform work without putting out some heat at a lower temperature. d) The entropy of an isolated system can never decrease.

This Law implies that the energy available to do work (the "available energy") decreases with use - that perpetual motion of the second kind is forbidden. It also implies that "waste heat" is always produced whenever energy is used.

A physical implication of this Law is that available energy is "used up". Hence we cnnot use more energy than was initially stored in our "bank account" or than we receive as our current "income". (By "bank account" we mean the energy deposited in the earth in the form of nuclear fuels at the time of formation of the solar system, or in the form of fossil fuels via the incomplete biological photosynthesis-oxidation cycle since then. By "income" we mean the current influx of energy in the form of solor radiation. Our fossil fuel account is just the net savings of our earth's previous solar income). Also implied is "heat pollution". Even if our energy bank account were infinite, allowing us to do an indefinite amount of desired work, the waste heat produced with each useful energy transformation will lead to an increase in the temperature of our terrestial environment with incompletely known but malign consequences. Other forms of pollution - garbage and sewage - represent increased entropy; energy must be withdrawn from our limited savings or income to reduce this entropy, to recycle the resources and diminish the material pollution.

The moral implications of the Second Law are quite different from those of the First. What we use up today will *not* be available to our posterity - if we use up the fossil fuels, they will have none. Many unknowns stand in the way of a meaningful estimate of the total amount of fossil fuel energy eventually available to mankind. However, we can arrive at an upper bound by recognizing that the creation of fossil fuels by photosynthesis is accompanied by the production of oxygen. Assuming that all of the oxygen free in the earth's atmosphere and trapped in the surface of the earth's atmosphere and trapped in the surface of the earth's crust stems from the creation of these fuels, we obtain for them an upper limit amounting to about 8.7×10^{18} kilowatt hours[3]. (Obviously, even if this much fuel actually existed upon earth, not all of it would be usefully reachable. Some estimates[4] say only 1.5% of this upper limit is potentially recoverable). If the world were to use energy at a *constant* rate of 7×10^{13} kwh per year (as it did in 1970[4]), and if all of this energy were obtained from fossil fuels, we would use up all of our fossil fuels in less than 10^5 years, a period small compared either to the creation time of these fuels or to man's time on earth. If, instead of a constant rate, the demand on our fossil fuels grew exponentially at the fixed predicted increase rate of 8.75% per year[4], these fuels would be gone in less than 106 years. (At the smaller U.S. rate of increase, 3.75% per year, the maximum lifetime of our fossil fuels would be 224 years). Thus a policy of exponential growth leads to radically different results than a policy of steady withdrawal from our fossil energy bank accounts. Even the latter policy must sooner or later be changed, e.g. to a policy of living off solar income.

The Second Law also implies that as we use up fossil fuels we produce waste heat; this leads to an increase in the earth's temperature T which can be estimated using the Stefan-Boltzman radiation law[3]. Our total solar energy income is $_s = 1.56 \times 10^{18}$ kwh/year. If Q_F is the rate at which we burn our fuels, the total rate of heat delivery to theearth is $Q_s + Q_F$. This must equal the rate at which energy is radiated from the earth. At a constant rate of increase of 8.75% per year, $Q_F = 5.6 \times 10^{15}$ kwh per year in 50 years, 4.4×10^{17} kwh/year in 100 years. Thus in 50 years we would expect a temperature increase of only 0.025°C. But at the end of 100 years the earth's average temperature would have gone up by 15°C, certainly enough to melt much of the polar ice caps and flood much of the earth's cities and plains.

Also accompanying our use of fossil fuels is the depletion of our free oxygen and an increase in the carbon dioxide content of the atmosphere with its accompanying greenhouse effect[5]. Finally, the Second Law tells us that as we use up our resources and pollute our environment we raise our entropy. We will then have to use more and more energy to repair these damages - to decrease our entropy.

In the usual physics classroom, these laws of thermodynamics are presented as straight physics. Local problems, e.g., heat engines, or refrigerator efficencies, may be assigned, but seldom is any effort made to look at universal human problems. Raising the moral implications of these laws is to make them "relevant" to today's students, so gaining their attention and easing the tasks of teaching. The meaningfulness of the subject should enhance its catching and staying power in the students' minds. When we couple the desire to "know" with the desire to "use, we are fully exploring the science we endeavor to teach.

Should this converse relation, between science and ethics, be taught in non-science classrooms, e.g., economics and political science? Such students are being taught to make the practical decisions of society, decisions made on a "cost-benefit" basis where both cost and benefit are expressed in monetary terms. But money is not an absolute quantity - in these inflationary times, its "value" is constantly changing. Money is just a *promise* to provide goods and services and there is no limit to the promises we may make each other. But there is a limit, based upon the availability of energy and resoruces, to the promises we can keep. The difference between promises made and promises kept is a major cause of inflation[6]. Realistic priority setting, both private and social, should be based upon measures of value which are themselves not changed by the decision. Energy is such a measure of value and hence energy expenditure is a better measure of cost than is money. Energy expenditures are governed by the Law of Thermodynamics and so it follows that these laws and their ethical consequences should be taught to non-scientists also.

The basic question of ethics is "how do we divide up the world" between people and generations, where by "world" we mean a great deal more than just the physical world is an important determinant of the more complete "world" and that our knowledge of the former must be brought to bear on any discussions of the latter. Until politicians, economists, business men, churchmen, and other determiners of our social ethos are more familiar with the results of science, scientists must bring ethics into their classrooms and must their classrooms to all students.

Footnotes

[1]E.g.W.K. Hartman, ASTRONOMY: THE COSMIC JOURNEY, (Wadsworth Publishing Co., Belmont, Cal., 1978) p.298.

[2]Galileo,.as quoted in G. De Santillana, THE CRIME OF GALILEO, (Univ. of Chicago Press, Chicago, 1955) p.9

[3]See, for example, A.M. Saperstein, PHYSICS: ENERGY IN THE ENVIRONMENT, (Little, Brown and Co., Boston, 1975).

[4]S.S. Penner and L. Icerman, ENERGY, VOL. I. DEMANDS RESOURCES, IMPACT, TECHNOLOGY, AND POLICY (Addison - Wesley Publishing Co., Reading, Mass., 1979) pp 13-16, 12.

[5]Council on Environmental Quality, GLOBAL ENERGY FUTURES AND THE CARBON DIOXIDE PROBLEM, (U.S. Government Printing Office, Washington, D.C. 1981)

[6]A.M. Saperstein, Bull. Atomic Sci., *36*61 (1980).

28.2

THE ECONOMIC ISSUES OF THE ENERGY CRISIS

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Abstract
This paper focuses on the importance of including economic issues in energy education programs. The OPEC oil embargo in 1973 brought the world's attention to the energy crisis. America responded to the crisis with government controls and conservation programs. The consequences of these policies are easily understood when basic economic principles are considered.

Introduction
In the fall of 1973, the Organization of Petroleum Exporting Countries (OPEC) imposed an embargo on shipments of oil to many of the industrialized nations of the world. The increases in the price of crude oil which resulted substantially raised the cost of energy. Suddenly, the world became aware of what has come to be known as THE ENERGY CRISIS.

The Club of Rome's warnings about "limits to growth" became a painful reality to people around the world. The future looked bleak. It seemed that the Earth's finite resources could no longer support man's insatiable desire to achieve an ever higher level of affluence. People were told that conservation was the only way out of this dilemma.

And, yet, the American people did not seem to be responding properly to this national crisis. When asked, many Americans responded that they did not believe the crisis was real. The question of the day became, "How can people be convinced to conserve energy so the comfortable life style of our technological society can be maintained?" The answer lies, to a large extent, in a better understanding of the economic principles involved in the energy crisis.

America's response to the crisis
In the United States, the immediate reaction to the oil embargo was to turn to government control rather than allow the market system to operate. The groundwork for such an approach had been laid in 1971 when President Nixon imposed price controls on most products, including gasoline, in an effort to fight inflation. When OPEC's embargo hit, the controls on petroleum products were extended, even though they were being eliminated from all other products. The Federal Energy Administration Act of 1974 created the Federal Energy Administration (FEA) and gave it authority to allocate fuel and regulate prices. This was done in an effort to protect consumers from rising gasoline prices. This was soon follwed by the Energy Policy and Conservation Act of 1975, which expanded the government's role in the nation's energy industry. In addition, it also provided for the decontrol of crude oil prices within 39 months. However, when the time came for decontrol to become a reality, many Americans feared that the oil companies would receive excessively high profits at the expense of consumers. The nation's answer to this supposed injustice was the windfall profits tax.

What was happening in the economy during this time? On several occasions, gasoline shortages occurred. While the American people spent many hours in long lines, various forms of rationing were tried. At first, gas stations closed on weekends or whenever their monthly allocation was exhausted. Some states tried odd-even rationing. Finally, in 1980 the President was given the authority to implement a national gas rationing plan in the event of a severe shortage.

Did the problems of the 70s occur because of a lack of effort to get the American people to conserve energy? No. The federal government took direct action to get people to practice conservation—the speed limit was lowered to 55 mph, regulations were passed concerning thermostat settings, new cars were required to attain ever higher mpg ratings, and tax credits were given for insulating one's home. On the local level, cities tried various methods of encouraging people to carpool. Los Angeles, for example, reserved one lane of its freeways during rush-hour traffic for cars with three or more passengers. However, this experiment did not last long because few people took advantage of the "carpool" lane. In addition to these direct approaches, much time and effort was spent on advertisements, booklets, and programs designed to show people various ways they could conserve energy. Unfortunately, most of these efforts fell short of the expectations of those who planned them. Why didn't Americans make the effort to conserve energy in the face of this national crisis?

Basis econoic principles
Economics has a great deal to say about what has occurred since 1973. As a science, it cannot determine if a particular response to the energy crisis is good or bad, right or wrong. It can only help shed some light on what to expect when a certain policy is pursued. Knowing what is likely to occur, it is then up to each individual to decide which approach to our energy problems is best.

One of the simplest and most powerful tools of the economist is a supply and demand diagram. It can used as an effective educational aid to help students understand the economic implications of various energy policies. In using this diagram it makes little difference what product or industry is being examined. The basic economic principles remain the same. Since most students are familiar with gasoline, a hypothetical situation in this industry can be used to show that, for the most part, the actions of Americans during the 1970s was what economists would expect.

A diagram shows that the demand curve is downward sloping, reflecting the observation that as the price of an item declines, people want more of it. The supply curve indicates that as the price of an item rises, producers are willing to supply more of it. In this diagram, equilibrium occurs at a price of $2.00 per gallon. (The actual numbers and units used here are hypothetical and are irrelevant to the basic analysis involved. What is important are the basic economic principles involved.) At the price, consumers want 300 gallons and producers are willing to supply 300 gallons. At a price of $2.00, then, there are no forces working to either increase or decrease the price of gasoline.

Suppose the government decides to protect the consumer from high prices by setting $1.00 as the maximum price which can be charged for a gallon of gasoline. There are two important implications of this action. First of all, consumers want to purchase more gasoline than they did at $2.00 per gallon. They now want 375 gallons. Secondly, producers are not as eager to supply gasoline. They will produce only 200 gallons. At a price of $1.00, then, a shortage of 175 gallons would exist.

In the market place, price plays a very important role in determining the allocation of scarce resources. It acts as a signal to both the buyers and the sellers. When the price is low, it tells consumers that the item is plentiful relative to the demand for it and encourgages then to use more of it. A rising price signals that the supply is becoming more scarce relative to demand and encourages people to use the item for only its most valuable uses. Low prices discourage producers from supplying much of the item, while higher prices encourage increased investments and higher levels of production.

This simple observation helps explain much of what happened in America after the 1973 oil embargo. Regulating prices to protect consumers actually encouraged them to consume more gasoline while at the same time it discouraged domestic producers from making more gasoline. Americans did not believe the energy crisis was real, in part because the low prices they saw in the market place indicated that gasoline was plentiful. By discouraging the domestic production of crude oil, American became increasingly more dependent on foreign oil. The long lines experienced at gas stations were the real world counterpart of the 175 gallon shortage in the simple supply and demand diagram. The various rationing plans proposed were simply different methods of trying to deal with this shortage.

How do economists view energy conservation and the wise use of limited resources? The diagram above has something important to say about that, too. If the price of gasoline were allowed to rise to the market equilibrium price of $2.00 two things would occur. First, consumers would reduce their consumption of gasoline, using it only for its most valuable purposes. The higher price will provide an incentive for people to conserve this scarce natural resource. Second, it will tend to encourage oil production, thus reducing America's dependence on foreign oil. Both of these factors work toward eliminating the shortage which would occur at the price ceiling of $1.00 and thus reduce the need for some type of rationing plan. The higher price will, in essence, ration the scarce resource to its most important uses.

A third issue becomes important here. Through much of the 70s there was a great deal of discussion concerning the development of alternative energy soruces — synthetic fuel, gasohol, nuclear, geothermal, and solar power. As long as the price of gasoline (and natural gas) are kept artificially low, there is little or no economic incentive to make the large investments and undergo the tremendous risks which the development of these alternative energy sources represent. If the price of current energy sources are allowed to rise, these alternatives will become economically feasible. Only then will the full force of economic incentives help solve the current energy crisis.

History provides an example of how the economic principles discussed above operated in a previous energy crisis. During the eighteenth and early nineteenth centuries, whale oil was a widely used lubricant and the major source of illumination in America. As the demand for this product increased, the rising price encouraged the investment necessary to build the larger ships needed for deep water whaling near the Arctic Circle. By the middle of the nineteenth century, the American whaling fleet averaged 600 ships or approximately 12% of the non-agricultural workforce and represented an investment estimated at $70 million. As the price per gallon rose from 88¢ in 1846 to $2.55 in 1866, people sought ways to reduce their use of whale oil and began searching for substitues, mainly coal oil and petroleum. As these alternative energy sources began to be harnessed for practical use, the demand for whale oil declined. By 1886, the price of whale oil had fallen to 74¢ per gallon and American's whaling fleet declined to 70 ships by the end of the century. This transition from whale oil to alternative energy sources relied mainly on market forces rather than government control.

Conclusions for energy education programs

Part of America's response to the energy crisis has been the creation of a wide variety of energy education programs. Detailing the history of the energy crisis, emphasizing the need for conservation, describing altenative energy sources, and teaching students various techniques for conserving energy are certainly important parts of these programs. However, these subjects merely teach students how to make the current situation a little more tolerable. They say nothing about the potential effectiveness or implications of the various energy policies available to us. If the goal of education programs is to help students solve the energy crisis, then they must include discussions of the economic issues involved.

Education programs must go beyond simply observing that energy costs are rising, that the economies of most nations have been adversely affected by increased energy costs, and that people are unemployed as a consequence of the crisis. They must look into both the advantages and the disadvantages of allowing the market to operate verus relying on government planning and control. What types of programs has the Department of Energy (DOE) pursued? Have these programs helped or hindered efforts to solve the energy crisis, to shift to alternative energy sources? How profitable is the oil industry? Even though its nominal price has steadily risen, what has happened to the real price of gasoline? Should oil companies be allowed to develop alternative energy sources? Is the windfall profits tax really a tax on profits or simply an excise tax? What role does risk play in investment? How responsive is the demand for gasoline to changes in its price? A simple diagram like the one above can go a long way in helping students understand the economic principles involved in many of these questions.

A program which includes these economic issues will assist students in determining for themselves if a particular policy will help or hinder efforts to conserve energy, whether it will stimulate or discourage the development of alternative energy sources. Then, and only then, will energy education programs make a positive contribution toward solving the energy crisis.

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28.3

THE REAGAN ADMINISTRATION ENERGY PROGRAM: A STUDY IN ECONOMICS AND POLICY

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Introduction

The Reagan energy program was announced in an executive order on January 28, 1981. Its principal provisions included (1) immediate decontrol of oil and gasoline prices (2) ending the gasoline allocation and refinery entitlements programs (3) reducing federal financial aid to synthetic fuels projects (4) reducing federal support for conservation and, (5) opening more public lands and acelerating the pace of offshore oil exploration. One special feature of the program is the emphasis upon greater reliance upon the market price system instead of government bureaucratic direction in the energy field. The focus of this paper is to review the main provisions of the program with particular emphasis on petroleum using some of the basic concepts of macro and micro economics.

The Setting: Macroeconomics and Oil Shocks

Professor Walter W. Heller, former Chairman of the Council of Economic Advisers has said that a supply debacle in the nineteen eighties is not inconceivable. "The potential supply debacle basically boils down to one word: oil. A major sustained cut-off of Mid-East oil could for a time plunge us into a supply-side depression."[1] Large and persistent disruptions could badly damage the nation's productive capabilities.[2]

The United States has experienced oil price shocks since 1973. The direct cause has been oil price increases; these increased sixfold between 1973 and 1980. The shock can also be measured by measuring the ratio of oil imports to GNP. This increased from less than ½ of 1 per cent in the early 1970s to almost 4 per cent in the 1980s. The Arab oil embargo of 1973 and the Iranian oil cut-off of 1979 were of course the underlying causes of these price changes. When one considers that our total oil import bill is now equal to the entire corporate income tax revenue it becomes apparent that a sum of this magniture cannot avoid having major macroeconomic repercussions.[3] Oil imports from the Organization for Petroleum Exporting Countries (O.P.E.C.) represent an oil tax or drag for the economy. This tax siphoned off an extra $30 billion net in 1980, an amount that will probably double in 1984.[4] This has deflationary effects on the nation's economy because at the margin one dollar spent by us for oil will return $.50 at most. Demand is thus diverted away from our markets. This is why an energy program that can reduce our oil imports has significance in terms of improving our trade balance.[5]

Another important macro-economic effect of rising oil prices is that it intensifies the public's expectations of future higher energy prices. In turn this only hardens wage demands among workers and professionals and intensifies cost pressures that underly wage and price inflation.

Prive System vs. U.S. Price Controls

Michael T. Halbouty, the chief architect of the Administration's energy program says that the keystone of the program must be the free market system.[6] This means allowing the domestic price of oil to rise to the level set by the Organization of Petroleum Exporting Countries. This is a group of countries that has succeeded in organizing a pricefixing and market-sharing arrangement. According to Professor Milton Friedman, the quadrupling of the price of oil in 1973 by the oil cartel transmitted essentially the message that OPEC now had these ability to fix prices and allocate markets.[7] However price controls on oil and other forms of energy by the U.S. government in their turn prevented information about the effect of the OPEC cartel from being transmitted accurately to users of petroleum. The effect was to strengthen the OPEC cartel by preventing a higher price from encouraging Americans to economize on the use of oil. It also required the introduction of large command elements in the United States in order to allocate the scarce supply. The Department of Energy's 1979 budget was about $10 billion and it employed 20,000 people.[8]

Professor Friedman's views on distortions of the price system are accepted by many people in the business community and the energy industry. But does decontrol now mean that the oil prices set by OPEC countries will now enable American consumers and industry to make better decisions in spending money for gasoline, heating oil and energy for industrial use? The Administration's energy advisers would answer affirmatively to this question and so would the oil companies. The latter felt hedged in when the gasoline allocations programs was in effect. Instead of being able to make decisions on gasoline allocations on the basis of market conditions they felt that the government's complex system of rules made it difficult for them to avoid creating regional shortages. This program was established in 1974 after the Arab oil embargo because it was feared that during a future shortage the oil companies would use their power to eliminate market competition by denying gasoline to private brand dealers.

From a free-market perspective the allocations program represented the substitution of command economy elements for a market price mechanism that would be more responsive and sensitive to such factors as population shifts, changing market preferences and numerous other market variables.[9] The allocations program never was satisfactory and its inherent weaknesses were especially noticeable during the Iranian oil cut-off.

Refinery entitlements also ended with decontrols, which was inevitable since it too substituted bureaucratic rulings for market forces. Large refiners able to buy domestic price-controlled oil were required to subsidize other refiners dependent on high price foreign oil. This would equalize costs of oil to all refiners as part of an effort to hold down oil prices. The large refiners-representing the large oil companies complained that the subsidies they paid were helping to sustain a large number of inefficient refineries. Survival was not even related to economic efficiency or the ability to adapt to changing market conditions.[10] Consequently the gasoline allocations system and the refinery subsidies were bound to end once bureaucratic rulings were replaced by a market place philosophy.

The Decontrol Debate

The debate over whether or not to decontrol oil prices has been going on ever since 1971, since oil has been under one form or another of price control since then. The advocates of decontrol have presented the following types of arguments: (1) it would avoid oil shortages (2) it would create incentives to discover new oil supplies (3) it would reduce oil imports and encourage energy conservation (4) it would let oil prices more closely reflect the true costs of this resource. In the Harvard energy study, *Energy Future*, the microeconomic concept of externalities or social costs induced by higher imports are given considerable attention. These are costs not borne by individual oil consumers because they aren't included in market prices. Included in these externalities are such conditions as slower national economic growth and international political tensions.[11]

The proponents of controlled prices have asked whether higher prices will not penalize certain low income groups in the population relative to more affluent ones.[12] They also ask whether energy poor regions such as New England are not going to suffer relative to the more energy affluent ones.[13] They also believe that decontrol is just another windfall gain to the rich and powerful oil companies whose chances of finding more oil are no better with these extra profits than without them. There is also the belief that decontrol implicitly sanctions unrealistic price increases among the OPEC producers. If those countries know that the U.S. will let its domestic oil prices rise to the "world level", then who is to say what that level should be? Since neither the Administration nor the multinational oil companies can prevent pricing disunity within OPEC, it is inevitable that world oil prices will rise, especially when the temporary world surplus begins to diminish.

Decontrol, Conservation and Oil Production

Mr. Halbouty recently said "I don't want to leave the impression that conservation measures are not important...They are important...but production is the main key to supply our energy needs."[14] As recent experience shows, the cumulative impact of higher oil prices (through OPEC and decontrol) via the price mechanism has already proved quite effective in conserving energy. Imports have fallen from 9 to 6 million barrels a day. On this point it is noteworthy that both the *Ford Foundation* report of 1974 and the Harvard Business School's *Energy Future* study both undervalued the ability of the market place to stimulate conservation and overvalued government policies.[15]

However there are uncertainties about the current conservation trend. It is conceivable that it may begin to weaken if the economy's growth picks up and encourages greater energy demand. It is ironical that conservation could actually be threatened by having more moderate price increases instead of the kind that tend to shock the economic system.

The microeconomic concept of price elasticity of demand measures the relative responsiveness of consumers to relative changes in price. Applying this to conservation, we find that the short run elasticity coefficient for gasoline is about 0.1 while the long run value is about 1.5.[16] The difference can be explained on the basis of a fixed stock of energy using equipment in the short run with fixed fuel efficiency characteristics. Both of these can change in the long run. Two alternatives to higher gasoline prices are fuel taxes and taxes on the efficiency of cars. The second of these is preferred because it avoids large income transfers and still reduces fuel consumption.[17]

While higher oil prices have tended to slow down oil imports it is not clear at all whether they will result in significant new discoveries of oil. The possibility does exist but America's petroleum history provides precious little evidence for the proposition that discovery is a function of price. If there is a relationship, it seems to be an inverse one. When some of this country's greatest oil finds were made in East Texas in the early nineteen thirties, the price of oil reached its all time low. When import quotas artificially boosted the domestic price of oil during the years 1959-1972, the discovery of new oil fell below the rate of the preceding decade.[18] We also know that price increases since 1973 have been accompained by a steady decline in new oil discoveries. In 1980 alone, Exxon, Gulf, Sohio and Texaco all found less energy than they produced.[19]

Producers' and Consumers' Surplus

The economic concept of "producers' surplus" is defined as "the difference between the amount actually received by the producers and the minimum amount necessary to bring forth the relevant output."[20] In the case of developing new reserves in high-cost regions, the costs of exploration are, according to the *Wall Street Journal*, going to outstrip even the oil industry's swollen earnings.[21] Historically these have been ploughed back into exploration. So the prospects are that there will be no producers' surplus for most companies in the near future. This type of surplus would accrue to oil producers for low-cost oil found may years ago.

On the demand or consumer side there is the concept of "consumers' surplus" which represents the difference between the amount buyers are willing to pay and the amount they actually pay."[22] This idea is usually linked to monopoly pricing with the implication that such market pricing causes a loss to consumers in money or utility terms. In this context its application would be to determine if decontrol will cause greater losses of consumer surplus for some families than others. Decontrol raises the issue of a possible conflict between the goals of increased energy supply and income equity. Separate policies can be designed to address each of these.[23]

Offshore and Public Lands Development

It is expected that leases will be offered to open the development of offshore California together with public lands in Alaska. The private market profitability of these ventures would tend to consider only private benefits and costs. Environmental costs would tend to be ignored.[24] By focusing on private benefits and costs there is a risk of establishing an irrational order of priority that will have effects on "third parties"— people who are not parties to the oil exploration and development venture. When third parties have had involuntary losses imposed upon them, refer to this as an example of "market failure".[25]

Professor Milton Friedman says that government is one means through which we can try to compensate for market failure so that we use our resources more effectively to produce the amount of clean air, water and land that we are willing to pay for.[26] Although he is willing to admit that government has a role to play, he points out that attempts to use "government to correct market failure have often simply substituted government failure for market failure." His summary statement is that the "imperfect market may, after all, do as well or better than the imperfect government."[27]

Synthetic Fuels

Fuel from tar sands, coal and shale make a great deal of sense if the production of synthetic fuel is cheaper than alternatives, taking account of private and environmental costs. Congress began an $88 billion program in 1980, establishing the U.S. Synthetic Fuels Corporation to spur commercial synfuels plants through a combination of government loan guarantees and purchase contracts. The Administration's objectives in this area appear to be that of keeping the synfuels effort alive but under the control of the oil companies. This would eventually eliminate subsidies, which as noted earlier, was one of the main objections of the Administration to the refinery entitlements programs. There is a very strong belief in the Department of Energy and the White House that the market is the best mechanism for determining whether synfuels can succeed. If it is cheaper than other fuels, then it will be in the self-interest of private companies to exploit this alternative, provided they reap the benefits and bear the costs. From a macroeconomic perspective, the synfuels program has many commendable investment and employment characteristics that would be lost if the program were completely terminated.

Conclusion

The Reagan energy program represents an effort to reduce America's dependence on foreign oil while it expands an energy base that would remain essentially invulnerable to politically motivated oil supply disruptions. In order to attain these goals, the program proposes to make extensive use of the price mechanism of the market place at the same time that it eliminates a maze of government controls and regulations that previously affected the nation's energy corporations. The real test of the program will be its ability to cope successfully with a future oil shortage. There are also questions concerning the relationship of decontrol to future efforts to restrain price inflation. The basic tools of micro and macro economcis help to illuminate and clarify the provisions of the new program and some of the problems that may arise in the future.

Footnotes

[1]Walter W. Heller, "Can There Be Another Crash?", *Introductory Macro economics 1980-81, Readings on Contemporary Issues*, ed. Peter D. McClelland, (Ithaca: Cornel University Press, 1980), p. 39.

[2]*Ibid.*, p. 40.

[3]*OECD Economic Outlook*, July 1980 (Washington, D.C.: OECD publications) has a special section "The Impact of Oil in the World Economy" containing much useful data.

[4]Heller, *op. cit.*, p. 40

[5]Robert B. Carson, *Economic Issues Today, Alternative Approaches* (New York; St. Martin's Press, 1980), p. 290.

[6]Michael T. Halbouty, "Some of Tomorrow's Needs for a Vital Energy Policy" *Vital Speeches* (February 1, 1981), Vol. XLVII, No. 8, p. 252.

[7]Milton and Rose Friedman, *Free to Choose, A Personal Statement* (New York: Harcourt Brace Jovanovich, 1980), p. 17.

[8]*Ibid.*

[9]Hearings before the Subcommittee on Energy Regulation of the Committee on Energy and Natural Resources, *Federal Gasoline Allocation Process*, United States Senate, 96the Cong., 2d sess., June 9, 1980, p. 147.

[10]Hearings before the Subcommittee on Energy and Power of the Committee on Interstate and Foreign Commerce, *Domestic Refinery Policy-Oversight United States House of Representatives, 96th Cong., 2d sess., December 17, 1980, p. 71.*

[11]Robert Stobaugh and Daniel Yergin (eds.) *Energy Future: Report of the Energy Project at the Harvard Business School* (New York: Ballantine Books, 1979), p. 54

[12]In 1978 an additional $120 billion or 6 per cent of the GNP would have been transferred from American consumers to American producers if all energy prices had been allowed to follow the price of imported oil. This calculation and a discussion of its implications are discussed by Professor Lester C. Thurow, *The Zero Sum Society: Distribution and the Possibilities for Economic Change* (New York: Penguin Books, 1980), pp. 29-31.

[13]William H. Miernyk, Frank Giarratani and Charles F. Socher, *Regional Impacts of Rising Energy Prices* (Cambridge, Mass.: Ballinger Publishing Co., 1978), pp. 41-48.

[14]Halbouty, *op. cit., p. 252.*

[15]Paul W. MacAvoy "A Telling Fallacy in Forecasting Oil" *The New York Times*, June 7, 1981, p. F-3.

[16]James M. Griffin and Henry B. Steele, *Energy Economics and Policy* (New York: Academic Press, 1980), p. 232.

[17]*Ibid.*, pp. 233-234

[18]John M. Blair, *The Control of Oil* (New York: Vintage Books, 1976), p. 323.

[19]These companies finished 1980 with lower reserves than they had at the end of 1979. The eight major il companies showed a 3.5 per cent decline to 15.1 billion barrels proved reserves. "Falling Energy Reserves" *The New York Times*, April 5, 1981, p. 18-F.

[20]Griffin and Steele, *op. cit.*, p.54

[21]"U.S. Oil's Cash Needs May Strain Debt Market", *The Wall Street Journal*, February 2, 1981, p. 19.

[22]Griffin and Steele, *op. cit., p. 54*

[23]*Ibid.*, pp. 233-234

[24]John V. Krutilla and R. Talbot Page, "Energy Policy from an Environmental Perspective", *Energy Supply and Government Policy*, eds. Robert J. Kalter and William A. Vogely (Ithaa: Cornell University Press, 1976), p. 80.

[25]Griffin and Steele, *op. cit.*, pp. 39-41

[26]Friedman, *op. cit.*, p. 214

[27]*Ibid.*

28.4

TEACHING ENERGY ETHICS IN A COLLEGE LIBERAL LEARNING PROGRAM

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Introduction
Union College is an independent, primarily undergraduate college offering academic programs in the liberal arts and engineering. In addition to the course requirements for the major, all Union College undergraduate students are required to complete several courses in the Liberal Learning program. These courses are generally outside the major field of interest of the student and are intended to provide each student with a broad intellectual background. A key objective of this program is to equip students for future decision-making roles that draw on the experience and skills developed through liberal learning. The purpose of this paper is to describe an energy course that has been developed for this program and which emphasizes energy ethics. It is noted that this course is open to all Union College undergraduate students regardless of their major or year of standing. In addition, there are no prerequisites for the course since all background information needed to understand the course material is developed within the course.

Readings
The course is based on an extensive set of notes,[1] written by the author, copies of which are provided to each student. The notes present ten energy principles dealing with 1.) The direct use of solar energy. 2.) Energy conservation in the home and in the community. 3.) adherence to public laws that conserve energy. 4.) Environmental pollution due to energy consumption. 5.) The effect of population growth on energy consumption. 6.) The wise use of nonrenewable energy resorces. 7.) The use of renewable energy resources when possible. 8.) The use of human muscle power when reasonable and effective. 9.) The elimination of wasteful practices. 10.) The importance of sharing energy knowledge and skills with other people.

Each energy principle is accompanied by a chapter which demonstrates how the individual can alleviate problems associated with energy shortages. Materials presented that deal with the ethical use of energy resources include the following:

a.) The first chapter deals with how the individual can make direct use of the sun's energy in supplying the basic human needs of warm water, comfortable buildings, dry clothing,and pure water. Many of these solar applications are very simple and involve only an individual commitment to use the warming rays of the sun to advantage. Examples of these measures include opening and closing window shades for warmth and light control, and using the sun to dry clothing. Other direct uses of the sun's energy require more planning and/or technology in order to better utilize solar energy. For example, when building or buying a home, consideration should be given to the amount of window space on the south wall of the house (for homes in the Northern Hemisphere) as well as the use of roof-top solar collectors for heating water and/or air.

b.) A major consideration in the chapter on energy conservation is the development of a personal energy conservation ethic. It has been stated that such an ethic is a conscious effort on the part of an individual to think in terms of wise and efficient use of energy whenever consuming energy resources. For example, before purchasing any product, a consumer should consider the following questions regarding the particular product in question:[2]

1. Do I really need it to be happy?
2. What could be used as a substitute or alternative?
3. Will buying it promote a more materialistic lifestyle?
4. Is it expensive, yet efficient, in terms of total cost?
5. How long will it last?
6. Can it be recycled?
7. What resources are in it?
8. Are the energy resources scarce or nonrenewable?
9. From what countries do the resources come?
10. Are there other resources which could be used to make it?
11. Did its production result in significant environmental/ecological damage?
12. Will its use result in significant environmental/ecological damage?

c.) The third energy principle is concerned with the responsibility of all citizens to adhere to the prevailing laws of the land that seek to conserve energy resources. That is, in times of crises, such as those imposed by severe shortages, governments are forced to enact laws for the common good of the public. The basic message here is that for any energy conservation regulation to succeed in being equitable and effective, it is necessary that all citizens cooperate in its implementation. For it is only by individual citizens working together towards a common goal that any nation can hope to ovecome adversity. As an example, it was the 1973-74 Arab oil embrgo that led the United States Government to enact the Emergency Highway Energy Conservation Act of 1974. This law has been effective in conserving motor vehicle fuels on all American highways by lowering the maximum allowable speed limit to 55 miles per hour. However, ever since its enactment, this law has been the subject of much controversy with compliance being a problem. It has been reported that as many as 88 percent of all passenger autombiles exceed the 55 miles per hour speed limit on the New York State Thruway.[3]

d.) The purpose of the fourth principle is to acquaint the individual with the environmental consequences of energy consumption. For example, it is estimated that approximately 60 percent of all air pollution is related to the use of energy. It is emphasized that one way to reduce environmental pollution is to use less of those energy forms that pollute our environment. This leads to a discussion of the environmental effects of electrical power plants and motor vehicles which is organized as follows:

I.) Enviromental Effects of Coal When Used as a Fuel for Electric Power Plants. This section discusses air pollution due to coal burning and the environmental consequences of coal mining.

II.) Environmental Effects of Uranium When Used as a Fuel for Electric Power Plants. This section discusses the risks associated with the operation of nuclear power plants due to accidents, radioactive waste disposal, and acts of terrorism and war.
III.) Environmental Pollution Due to Motor Vehicles. This discussion covers the types of exhaust emissions from motor vehicles and steps that can be taken by individuals to minimize these emissions.

e.) The fifth energy priciple is concerned with the effect that population growth has on the world demand for energy. That is, the future of mankind on earth is largely dependent on two factors: world population and energy supply. As world population continues to increase, many problems arise due to the additional demand for the limited energy resources of the earth such as the threat of armed conflict and nuclear war, severe environmental pollution, continued inflation, and increased famine. This topic concludes with a discussion of how the individual can help to alleviate the problem of world population growth.

f.) The sixth energy principle is concerned with the precious nature of the world's nonrenewable energy resources. The basic message is that the world's supply of coal, petroleum, natural gas, and nuclear fuels, is limited and, once consumed, there is absolutely no means of replenishing them. It is important, then, to make wise use of these nonrenewable energy resources. The wise use of these resources involves a number of considerations. For example, when used as a fuel, it is important to exercise energy conservation techniques such that maximum useful energy is extracted from the fuel as it is consumed. Also, each nonrenewable energy resource has its own specific advantages and mankind would be wise to take advantage of these qualities. An example is the valuable nature of petroleum when used in the large-scale production of food. That is , modern agriculture has become very dependent on petroleum to power farm machinery and to produce fertilizers and insecticides. A.A. Bartlett has summarized this situation by defining modern agriculture as "the use of land to convert petroleum into food."[4]

g.) The seventh energy principle deals with the role of renewable energy resources in providing future energy resources for the world's population. It is emphasized that these energy resources are especially important due to their capability to provide humanity with a continual supply of energy, provided efforts are made to replenish their stock. The discussion of renewable energy resources includes wood energy, wind energy, hydropower and energy from the oceans and space.

h.) The eighth energy principle views the human body as a solar engine, powered by renewable energy, and capable of performing many useful tasks through the generation of muscular power.It is noted, however, that there are many situations where reliance on human power alone is not reasonable or effective. The discussion of human muscular power includes the use of the leg muscles for walking and cycling, the cyling mechanism as a source of electrical power, and the potential health benefits to the human body from its operation as an energy source.

i.) The basic premise of the ninth energy principle is that virtually every product, whether naturally produced or man-made, requires energy to produce and therefore should not be wasted. This leads to the concept of a "conserver society" which minimizes wastes of all forms including energy and materials resources. The discussion includes how to recover the energy in solid wastes, the benefits of recycling lubricating oils, and how to obtain useful energy forms from animal and plant wastes. It is emphasized that with citizen participation, our society can become a *conserver society* where the "waste not, want not" ethic is a way of life.

j.) The tenth and concluding energy principle presented in this course is concerned with the importance of sharing, with other people, our knowledge and skills that conserve and effectively use our energy resources. That is, we all have a special responsibility to our present and future generations to share with them, not only the finite energy resources of the earth, but also the knowledge and concerns that relate to their effective utilization. Topics covered include how the individual can share energy information within the local community and on a world-wide scale. The latter topic describes the activities of Volunteers in Technical Assistance (VITA). VITA is a private, nonprofit development organization devoted to assisting low-income people throughout the world in achieving a higher standard of living. Since 1960, VITA has supplied information and assistance to people in more than 100 developing nations on various technical problems dealing with food production and renewable energy technology.

Outside Speakers
A number of outside speakers were invited to speak to the class in order to present expert opinion on various topics pertinent to the course. These included the following:

1.) A biologist lectured on the effects of acid rain in lakes and streams in particular areas of the United States and Western Europe.
2.) An engineer with the New York State Public Service Commission spoke on several aspects of using nuclear power plants to generate electricity in New York State. Topics covered included safety, nuclear waste disposal, fuel reprocessing, decommissioning of nuclear power plants economics.
3.) An engineer from the New York State Energy Office spoke on the use of wind machines to generate electricity on both a commercial and residential scale.

Films
The following films were shown to the class in view of their relevance to the course material:

1.) "A Conversation with M. King Hubbert". This 16mm film runs for 38 minutes and is available from the National Audiovisual Center, General Services Administration, Washington, D.C. 20409. The film features Dr. M. King Hubbert who is a scholar and expert on the fossil fuel resources of the United States. Dr. Hubbert reviews the limited nature of the American fossil fuel supply and the impact that this will have in the future.
2.) "The SL-1 Accident; Phases 1 and 2" and "The SL-1 Accident; Phase 3". Both of these 16mm films are available from the DOE-TIC Library, P.O. Box 62, Oak Ridge, TN 37830. They run 40 and 57 minutes, respectively. These films discribe an accident that occurred in 1961 at a small nuclear test reactor in Idaho. Three men lost their lives in this accident and the films attempt to explain the cause of the accident and what was learned from it. There is also an extensive viewing of the clean up process which included demolition and earth burial of the reactor building.
3.) "Energy and Morality". This 16mm film runs for 33 minutes and is available from Bitterroot films, Hammond Arcade, Misolua, MT 59801. Two basic concepts are presented in the film which have been expressed as follows:[5]

"There is the view (presented by the character of the father and by Joan Bird in her paraphrase of Howard T. Odum) that living things tend to develop patterns that maximize their use of energy and that therefore in human societies it is *economics that designs ethics.* The counter view (presented by Amory Lovins and E.F. Schumacher) is that *ethics can, or should, design economics.*"

The film also raises important questions concerning the relationship between the amount of energy consumed by a society and the degree of personal freedom, truth, and aggression in that society. Another valuable feature of the film is that a Study Guide and Narrative Script is available from Bitterroot Films[5] which assists in reviewing the many ideas presents.

Footnotes

[1]J.R. Shanebrook, Notes for the Liberal Learning Course, "Energy I", Union College, Schenectady, New York, U.S.A., Copyright, 1980.

[2]Anon., "Energy Consevation in the Home", The University of Tennessee Environment Center, Knoxville, Tennesse, U.S.A., 1977.

[3]C.M. Bruso and J.R. Shanebrook, J. Environ. Systs. 8, 13 (1978-79).
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28.5

COSMOLOGICAL AND GLOBAL PERSPECTIVES IN ENERGY EDUCATION

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Abstract
Most if not all of the numerous recent books and articles on "Energy" use a strictly pragmatic-practical approach while a similar number of books and articles on the "New Physics" are presented from a highly speculative-theorectical perspective. In fact, the "New Physics and Cosmology" appear to have stimulated a "Science Craze" reflected by the publication and success of more than half-a-dozen new popular science periodicals. Newtonian concepts deeply rooted in our common-sense like absolute space and time, classical determinism, and the existence of eternal, unchanging paricles of matter had to be abandoned; instead, we have now an expanding Universe with a beginning in time, the uncertainty of relations of quantum mechanics, and particles materializing and dematerializing out of or into "empty" space. Naturally, the classical energy concept and the two related principles of thermodynamics - energy conservation and entropy increase - have undergone related revisions. Is it legitimate to ignore these new perspectives in energy education, and if no, how and to what extent should they be taken into consideration? Could they have some practical implications? An attempt will be made to answer these questions.

Introduction
We are inclined to take "energy" for granted, and we are usually quite sure that we understand fully what the concept of "energy" means and implies - after all, a substantial percentage of our income pays for our use of "energy" in various forms. But when we read about the slow emergence of the energy concept in history, or when we try to apply it to the universe as a whole, we realize that there are problems and unanswered, or, perhaps, unanswerable questions. After all, mechanical and heat engines had been used widely since the early 18th century while the theory of such engines based on the concepts of energy and entropy, had only been formulated around the middle of the 19th century, and it took another 30 years until use of the word "energy" became widely and definitely accepted during the 1880's. This was only about one hundred years ago - the same decade when Heinrich Hertz in Germany discovered that electromagnetic waves were the carriers of a new form of energy - the energy of electromagnetic radiation.

How much attention should be devoted to historical, cosmological, and global aspects of energy in energy education? This will, of course, depend upon the type of course being taught, but it would certainly seem advisable to devote some time to such topics in courses of an academic nature. Related topics are nowadays not infrequently discussed in popular science periodicals now on display on almost every newsstand, and in various popular books. Sagan's "Cosmos" - book touching upon a number of related topics - reached a record 34 weeks on the non-fiction best-seller lists. But we can find strong arguments for such an approach already in one of the classics in the history of the energy concept, i.e., Mach's "Conservation of Work" published in 1872. Mach is the scientist-philosopher getting credit for the principle carrying his name, a principle linking the inertial masses of material particles to the overall distribution of masses in the universe - a principle accepted by Einstein as one of the cornerstones for his "General Theory of Relativity".

Mach suggests in his essay: "In science education there are two methods enabling us to cope with reality: either one takes the puzzles and riddles encountered in science for granted and learns to live with them, or one tries to gain a deeper understanding; but this is usually only possible if one follows their historical development. Unfortunately, it is quite customary in science education to present fundamental theorems in a way as if they were self-evident although frequently their formulation required mental struggles lasting thousands of years. There is only one way to real understanding: a study of the history of the problem."[1]

History of the Energy Concept
What are the roots of the "Principle of Conservation of Energy" which plays such a fundamental role in modern science? We are usually inclined to look for them in Newton's mechanics, but surprisingly, Newton himself was not at all interested in any kind of "conservation principles". His "clockwork" worked perfectly without them. The first scientist writing about such a principle was apparently Descartes

whose main contribution to science was his analytical geometry. In his "Principles of Philosophy" (1644) he writes: "Now that we have examined the nature of motion, we come to consider its cause... As for the first cause, it seems to me evident that it is nothing other than God Who... created matter with motion and rest in its parts, and Who thereafter conserves in the Universe by His ordinary operations as much of motion and of rest as He put in it in the first creation... He conserves continually in this matter an equal quantity of motion."[2]

But what Descartes had called "quantity of motion" is not energy but what we call "momentum - the product of mass times velocity". The correct identification of kinetic energy ($\frac{1}{2}mv^2$) as a conserved qualtity had been first achieved by the German scientist-philosopher Leibniz in a paper with a title of unusual length part of which reads: "...the Memorable Error of Descartes...Concerning the Natural Law According to Which They Claim that the Same Quantity of Motion is Always Conserved by God...", but Leibniz calls his new quantity not energy but "Vis Viva - Living Force". This paper[3] was published in the same year, 1686, as Newton's famous "Principia". But the derivation of the familiar conclusion "the sum of potential and kinetic energy is constant" from Newton's equations of motion was apparently first given by L. Euler in 1752 - a Swiss born scientist who spent most of his life in the service of the Russian czar. Still, the word "energy" is not used in any of these early papers, but even in the mathematically sophisticated formulation of Newton's mechanics by the French mathematician Lagrange published in 1811 - in all these writings energy is still "Vis Viva".

Oddly, we do find the world "energy" used in an almost modern sense in some non-scientific early writings. "Energy" is a Greek word meaning usually "action" or "driving power", but in an essay on "Energy and Feeling" believed to be written by the hellenistic-egyptian philosopher Hermes Trismegistos probably during the second century A.D., we read: "Energies, though in themselves incorporeal, are in bodies, and act through bodies... Things once called into being for some purpose or some cause...can never stay inactive of their proper energy. If bodies are on earth, they are subject to dissolution but must serve as places and organs for the energies. The energies, however, are immortal, and the immortal is eternally bodymaking, it is energy".[4] This sounds like a prophetic vision of Einstein's mass-energy relation.

Another intriguing use of the word "energy" with some modern implications can be found in William Blake's "Marriage of Heaven and Hell," one of his so called prophetic poems written in 1973[5]; "Without Contraries is no progression. Attraction and Repulsion, Reason and Energy, Love and Hate, are necessary to Human existence. From these contraries spring what the religious call Good and Evil. Good is the passive that obeys Reason. Evil is the active springing from Energy. Good is Heaven. Evil is Hell."

But the "Voice of the Devil" has something else to say: "Energy is the only life, and is from the Body; and Reason is the bound or outward circumference of Energy. *Energy is Eternal Delight."* This last sentence has been frequently quoted out of context. It makes a challenging class exercise to ask students to interpret this poem from a modern perspective.

Where and when does the word "energy" make its first appearance in the scientific literature? Apparently in a lecture of T. Young[6] published in 1845 where he says: "The term energy may be applied, with great propriety, to the product of the mass or weight of a body, into the square of the number expressing its velocity... This product has been denominated the living or ascending force (vis viva), since the height of the body's vertical ascent is in proportion to it; and some have considered it as the true measure of the quantity of motion; but althogh this opinion has been universally rejected, yet the force this estimated well deserves a distinct denomination." Still, Young's introduction of the word "energy" did not immediately catch on, although decades earlier J.L. Lagrange in 1811 and W.R. Hamilton during the 1830's had given Newtonian mechanics highly sophisticated mathematical formulations, and introduced mathematical symbols for various energy fuctions, T for kinetic energy, U or V for potential energy - Hamilton calls it force function - $L = T - V$, $H = T + V$, etc., without using the word "energy". Hence, it is a surprise to most of us to learn that conventional notation for some forms of mechanical energy predates the use of the word "energy" by several decades.

The first papers extending the concept of what we now call energy from mechanics to other fields of physics, primarily to heat, electricity, and magnetism, and pointing out, in particular, the equivalence of mechanical and heat energy, were written by R.J. Mayer in Germany and J.P. Joule in England in 1842. Both papers were rejected by the editors of the leading scientific periodicals in the the two countries as nonsensical although their contents proved to be quite correct from the perspective of a decade later. A paper developing the same ideas in greater detail was eventually submitted by a scientist-physician of established reputation, H. vonHelmholtz, to the Berlin Academy of Science in 1847, and accepted. Traditionally, this is the paper quoted as introducing the "Principle of Conservation of Energy". Then why did Helmholtz still use the title "On the Conservation of Force"(Kraft in German)? His presentation does distinguish clearly between force and energy in the mathematical formalism - so why not in the use of words? Elkana, the author of an excellent book on "The Discovery of the Conservation of Energy" comments:[7] "The answer simply is that he (Helmholtz) was not aware that there had ever been any confusion. In creating a new concept one has to think in, or work with, a set of other concepts; the locial connection between these two sets cannot be formulated in the same conceptual framework, but outside or beyond it." Similarly, Mayer had used the word "Kraft" and Joule "Vis Viva" of "Mechanical Power" where we would now use the word "energy".

The word "energy" was finally introduced in a way well defined for use in science and technology by W.J.M. Rankine, a Scottish engineer, in a paper "On the General Law of the Transformation of Energy"[8] published in 1853. It starts with the statement: "In this investigation the term *energy* is used to comprehend every affection of substances which constitutes or is commensurable with a power of producting change in opposition to resistance, and includes ordinary motion and mechanical power, chemical action, heat, light, electricity, magnetism, and hall the other powers, known or unknown, which are convertible or commensurable with these. All conceivable forms of energy may be distinguished into two kinds; actual or sensible, and potential or latent... The object of the present paper is to find the law of the *transformation of energy*, according to which all transformation of energy between actual and potential states take place." "Actual energy", a phrase rarely used today, comprehends a variety of forms of energy, kinetic, thermal, chemical, radiative, etc., while "potential" is used in the same sense as in modern scientific literature. The now so commonly used phrase "kinetic energy" makes it appearance in Kelvin's writings only in 1871.

Rankine does quote some of the early work of Kelvin and Clausius, and presents not only the "First Law of Thermodynamics", the "Law of Conservation of Energy", but also a version of the "Second Law" which he calls the "Law of the Efficiency of Machines". In fact, in 1852, Kelvin, then still W. Thomson, had published a paper "On the Dynamical Theory of Heat"[9] - later called 'thermodynamics' - in which he acknowledges Mayer and Joule's proof of the equivalence between hat and "mechanical work", but does not seem aware of Helmholtz' 1847 paper. Thomson later became Lord Kelvin, and is best known for his discovery of the absolute zero of temperature at - 273.150° C (-459.67° F) - the absolute temperature is measured in Kelvin degrees (° K). This discovery proved crucial for the later developments of thermodynamics and for the formulation of the "Second Law" But the final formulation of this law and the definition of 'entropy' was only given by Clausius (Germany) in 1865. He concludes his classical paper on entropy with the words:

First Law: The energy of the Universe if constant.
Second Law: The entropy of the Universe approaches a miximum.

Clausius explains his choice of the word 'entropy' as follows[10]: "I propose to call this quantity 'entropy' using a Greek word 'trope' meaning transformation or transmutation (German: Verwandlung). I have coined the word 'energy' since the two quantities to be defined by these words appears appropriate." Clausius' choice has become standard usage in modern science and technology. Both Kelvin and Clausius did consider the cosmological implications of the entropy concept, but more about this later. Let us first consider briefly the implications of the discovery of additional forms of energy, in particular, of the energy present in electromagnetic fields and of the energy carried by electromagnetic waves.

Global Implications of the Energy of Electromagnetic Fields and of Electromagnetic Radiation

The forms of energy considered during the initial formulation of thermodynamics were usually linked to material bodies or particles. Admitedly, the particles were frequently assumed to move in fields, either gravitational or electromagnetic, but these fields were still directly linked to mattter, and were not assigned any dynamical properties of their own. but in the same year 1865 when Clausius defined 'entropy', the Scotish physicist J.C. Maxwell published his famous equations of the electromagnetic field which did give dynamical properties to the field itself. Using these equations, Maxwell predicted the existence of electromagnetic waves and ratiation, and identified visible light as a particular form of this radiation. The existence of electromagnetic waves was experimentally confirmed by Heinrich Hertz in Germany in 1888. Inspite of being primarily an experimental physicist, Hertz did say: "In talking about Maxwell's equations of the electromagnetic field, one cannot escape the feeling that these mathematical formulas have an independent existence and intelligence of their own, that they are wiser than we are, wiser even then their discoverers, that we get more out of them than was initially put into them."

Indeed these same equations were used by Einstein in 1905 as the starting point of his "Relativity Theory" Experiments had suggested that the velocity of light, $c = 2.997925 \times 10^{10}$cm/sec, appearing in Maxwell's equations, had the same value for any observer regardless of his relative motion. Hence, Einstein assumed that Maxwell's equations had a broader range of validity than Newton's laws, adapted Newton's mechanics to Maxwell's theory, and thus obtained his famous relation $E = mc^2$.

Hence, material particles possess an energy of their own, and mass and energy become, in a sense, equivalent. But the frequently encountered statement of writers of semi-popular articles or books: "Mass is converted into energy" looks logically questionable. 'Energy' as such has no well defined existence of its own, but is always energy of something, and what really happens is the conversion of mass-energy into the energy of some form of ratiation. Relativity theory permits a clear distinction between matter and radiation, inspite of the fact that Max Planck in 1900 discovered the "quantization" of electromagnetic radiation: when its energy is absorbed or emitted, this always happens in multiples of the quantity $E = hf$ where h is Planck's "quantum of action" (6.6262×10^{-27}erg sec), and f is the frequency of the electromagnetic wave, i.e., its number of vibration per second. Einstein, also in 1905, postulated that wave packages of energy hf are present in electromagnetic radiation itself, and proposed to call them "photons". But, contrary to material particles, photons can never be observed in a state of relative rest; they do not possess rest mass as particles of matter do, and are always travelling with the velocity of light. Later developments suggested that it is impossible to trace the path of a photon between emission and absorption: hence, they can not be localized in the sense in which a material particle can be localized - when we do localize them in absorption, they cease to exist.

In the "New Physics", the word "global" is frequently used in opposition to "Local" - one talks about "local" and "global symmetries" In a related sense, "global" is used when McLuhan talks about our world having become a "Global Village" largely because of the widespsread use of electromagnetic waves for communication: such waves need only about ⅓ of a second to circle earth, and a second to reach the moon.

Around the turn of the century the electromagnetic spectrum was gradually extended over a vast range of frequencies from long radio waves to hard gamma rays, ranging over nearly 20 powers of 10. At frequencies determined by the relation $hf \quad m_ec^2$ where m_e is the mass of the electron, matter and radiation become somewhat interchangeable - colliding photons can produce electron-positron pairs; the corresponding wavelengths are about 100,000 times shorter than the wavelength of visible light - 10^{10} versus 10^{-5}cm. Another limitation of the localizability of photons even in interaction with material particles resulted from the joint use of the Planck and Einstein relations in the form: $hf = mc^2$. Hence, the particles themselves must have a frequency $f = mc^2/h$. This led to the conclusion and eventual experimental verification of the fact that a particle dualism" led to the derivation of the famous Heisenberg uncertainty relations one of which relates time and energy:

$$\Delta E \Delta t > h/4$$

This implies: If we need a time Δt to measure an energy, an uncertainty in the determination of the energy $\Delta E > h/4 \, / \Delta t$ is unavoidable. There is a corresponding uncertainty in the determination of the location of the particle. In 1935, the Japanese physicist Yukawa reversed the argument, and concluded that not only observations were subject to such uncertainties, but that they related to the workings of nature itself. He interpreted ΔE now as the allowable deviation from energy conservation during the duration Δt of a process involving elementary particles. The conclusion is that nature operates on "borrowed energy." Nigel Calder in his "Keys to the Universe" compares this with a familiar situation in economy[11]: "Every financier knows that a daring man with little money can borrow some, bet it on a horse or on the changing price of copper, and hope to make a profit before he has to repay the loan. Likewise, Heisenberg (or rather Yukawa) found more energy available for activity in the micro-universe than you would expect by miserly accountancy."

Eventually, it turned out that most, if not all, of the basic processes of interaction between 'fields' and 'particles', and, in particular, between photons and electrons, could only take place via transitions into intermediate, 'virtual' states of such short duration that in them energy does not have to be exactly conserved. If nature could not operate on borrowed energy, everything would come to a 'virtual' standstill; it might be worse than the 'heat death' in the distant future predicted by the entropy principle. If somebody could decree that nature had to operate on a balanced energy budget, it would be decreeing a lot out of existence. Are there valid analogies between the operation of nature and national economies? It might be of some interest to pursue such analogoes further.

Hence, a combination of relativity and quantum physics leads unavoidably to the conclusion that energy is neither exactly conserved nor exactly localizable. According to the Heisenberg uncertainty relations, material particles are not exactly localizable either but the energies in radiation fields are localizable to a much lesser extent than the energies carried by material particles. But is it justifiable to call these limitations of energy conservation and of localizability truly "global". They do become so in some versions of modern cosmology.

Cosmological Implications
Both Kelvin and Clausius did write about cosmological implications of the Second Law of thermodynamics[12]. If the Universe is inexorably running down, it must have a beginning which appears to contradict the First Law: "The energy of the Universe is constant." Engels, with Marx the cofounder of the philosophy of communism, says in his "Dialectics of Nature": "Clausius, if correct, proves that the Universe has been created, ergo that matter is creatable, ergo that it is destructible, ergo that also energy, or motion, is creatable and destructible, ergo that the whole theory of conservation of energy is nonsense, ergo that all its consequences are also nonsense." Engels was right, in a way, and should have concluded that "ergo, materialism is nonsense". Instead, he and Marx assumed the validity of the Hegelian law, the "Law of Transformation of Quantity into Quality" to counteract the "Second Law".

The German philosopher Nietzsche did not like the consequences of the entropy principle either, and tried to evade them by postulating "Eternal Recurrences". He states: "If the Universe has a goal, that goal would have been reached by now." Like most scientists and philosophers before 1927, he believes firmly that the Universe must have always existed. The concept of creation at a finite time in the past is for him a relic of the "superstitious ages". He concludes: "If materialism cannot escape this conclusion of a final state, then materialism is thereby refuted" - an intriguing contrast to Engels conclusion. But another philosopher of this period, Bergson (1859-1941) adopts a positive attitude towards the law of entrophy which is for him "the most metaphysical law of physics. He develops the idea of a force counteracting this law, his "elan vital" which leads to "creative evolution". A scientific formulation of some of Bergson's ideas was achieved by the Russian born Belgian scientist Ilya Prigogine, and won him the Nobel Prize in chemistry for his "Thermodynamics of Evolution"[12].

But scientific foundations for a new cosmology became only available with the development of the new 20th century physics based on relativity and quantum theory. Crucial was Einstein's formulation of his "General Theory of Relativity" in 1915 which linked space, time, and matter, and related gravity to the curvature of space-time. When a Russian physicist Friedman proposed a solution of Einstein's equations describing a finite expanding or contracting universe in 1922, Einstein did not like this at all, and tried in vain to prove that Friedman's solution was erroneous. When the Belgian catholic priest Lemaitre published a similar solution with a beginning in time in 1927 - the first version of a Big-Bang type model - Einstein eventually conceded its acceptability, in particular, since astronomical observations of the recession of galaxies seemed to confirm the validity of such a model. But still many scientists did not like a beginning of time of the universe, and so in 1948 Hoyle and fellowworkers proposed a steady state cosmology based on the postulate of "continuous creation" of matter and energy. Hence, energy conservation had to be abandoned in this type of cosmology while it had still been taken for granted in the Big-Bang type models. In one of them proposed by P. Jordan (Germany) in 1938, the energy problem was solved rather radically and simply by postulating a zero energy of the unvierse - positive matter energy and negative gravitational energy of the universe do, in fact, compensate each other to a considerable extent.[13]

A new phase in modern cosmology started with the discovery of the so called cosmic background radiation of 2.7° K by the Americans Penzias and Wilson in 1965. This led to the formulation of the so called standard model with a initial fireball containing mostly high energy electromagnetic radiation. At the end of the first second after "creation" the universe contained about 10^{90} photons and 10^{80} nucleons of similar energies. Why and how this ratio had been established is not yet quite clear, but it appears to be related to the violation of some symmetry principles. With further expansion of the universe, these two numbers remain approximately constant, but while the energy content of the nucleons is fixed, the energies of the photons decrease with the expansion of the universe. After about one million years, the energy content of matter and radiation is about the same, but from then on the universe is "matter dominated". In fact, practically all the energy which we are using today derives from this matter energy which had represented less than one billionth of the total energy of the universe at the end of the first second of its existence. The huge energy content of radiation had been compensated by a similarly huge negative gravitational energy of the early univese.

In the standard model, energy conservation is still taken for granted, but the huge initial positive and negative energies seem somewhat unlikely. Nonstandard models permit both variation of some of the fundamental constants, and some violation of the symmetry principles including energy conservation. A more detailed discussion of the energy of the universe according to these various models is in preparation and will be available in the future.

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SESSION 29: CURRICULUM AND ASSESMENT II

ENERGY EDUCATION IN HIGH SCHOOL - SAVINGS AND RESOURCES, A PIAGETIAN WAY

by

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ABSTRACT

The recent energy crisis developed a worldwide concerned view of the importance of energy in life and development of Man. The interest in new alternative nonpolluent and cheap energy resources is apparent in scientific literature and in educational projects. Here, school has a tremendous responsibility. The correlation of the different factors and the full understanding of this complex issue requires a highly developed cognitive level, which is denominated by abstract or formal thought. Piaget epistemologic theory defends that the transition from former concrete to formal thought occurs sometime between 12 and 16 years of age. Accordingly, teaching strategies used in high school become extremely important since they may be responsible for promoting an earlier transition from one stage to the other. Both experience and social interaction are determining steps in the construction and reinforcement of more complex mental structures and the technique denominated by learning cycle is strongly recommended. Activities are presented meeting the methodology of that cycle which may be included in courses of Chemistry, Physics or Energy.

I. INTRODUCTION

The technologic development of Society and inherent improvement of living conditions of Man have produced an increase in energy needs. In recent years, the energy balance has been destroyed by that demand, oil shortage and high prices. Deep changes have occured in resources, conservation, storage and transmission of energy, however deeper changes have to be introduced in education namely curricula and methodology.

II. ENERGY PROBLEM

Accidents in nuclear power plants[1], themselves potential targets in international conflicts, have been changing official and public opinions from an optimistic to a pessimistic view of our future as human beings, members of a Society. In part, an uncritical acceptance of nuclear power, considered for a while the energy of future, has led to many of the subsequent difficulties of this technology. Consequently, it is fundamental that in the selection of energy sources all factors involved are considered, instead of considering just costs and availability. Production of energy and energy-dependent activities, regardless the technologies used, creates environmental disturbances, whose harmful effects in human health and ecological equilibrium are not considered seriously, until they have become widespread and made a number of victims. To prevent those effects, actions have to be taken, but since they usually require additional consumption of energy, costs increase and the improvements are ignored.

The two main points to be considered here are resources and conservation. Obviously, demand may be reduced, just by using more efficiently the available energy in conventional government and industry projections, but also in every day life of all the citizens. However, the choice of the most convenient energy supplies is still a controversial issue. The nonrenewable sources, like coal, petroleum, natural gas, nuclear fission and fusion, and geothermal energy have a dominant place over renewable sources, such as solar energies, wind energy, hydroelectric, biomass and ocean energy resources, in spite of their supremacy in terms of conservation, ecological equilibrium and availability. Also, the type of resources that are most appropriate for meeting the demands depend greatly of institutional factors[2], i.e., nontechnological characteristics of a society, for example cultural patterns, educational systems, industry and government organizational structures and agricultural practices. Namely, an institution may depend heavily on certain technologies, but not actually develop new technologies. Obviously, conflicts break out through the various goals that Society establishes for meeting its energy needs.

III. LEARNING PROCESS

We understand that responsable judgement criterias must have their fundamentals in scientific background transmitted in high school, since the potentiality for the development of advanced thinking patterns, what is called in Piaget's epistemologic theory[3], abstract or formal operational thought, develops between 12 and 16 years of age. For Piaget, the stage of formal operations is the highest level in the development of mental structures, hypothesized "mental blueprints" that guide the organism's behavior, i.e., they function to organize the environment so that the organism can function successfully in it.

In the course of intellectual development from infancy to adulthood, these mental structures are constructed and reconstructed within the brain and they determine in a sense how and what we think and the person we are. In fact, they represent our knowledge. Meaningful learning does not come from simply making a mental record, without the development of a mental structure. Things which seem obvious are simply not perceived whether the task is just to understand the concept of heat content of a reaction or grasp the idea of ecological equilibrium.

These mental structures are not present at birth (except very primary ones). They are constructed and reconstructed with time and the actions provide the patterns when internalized to the construction of mental structues. By the process of self regulation, the construction, reconstruction and reinforcement lead to progressively more complex and powerful thinking patterns. Self regulation depends on three main factors, experience, social transmission and maturation. In regard to experience, this factor helps students to build operational structures that can make them think abstractly about the world around them. It is the manipulation of materials of the discipline that produces the person who can understand abstract contents and not studying abstract contents that produces students who are able to interact with materials and invent abstract generalization. So, in science teaching, laboratory must proceed the introduction of an abstract generalization.[4]

Students who have not acquired formal reasoning patterns are severely limited in their ability to comprehend concepts[5] such as ecosystems, growth rate, enzimatic activity, etc. In college and high school their number may be as high as 50% of a sample. How can this sort of citizens, future voting members of Society, take responsible decisions in complex situtations, such as energy resources, costs v.s. environment protection, based on objective criteria. Dealing with costs constitutes a concrete problem, however probabilistic forecast, prediction of possible ecologic disturbances, correlated effects of saving strategies, etc. require high developed thinking patterns.

The instructional technique learning cycle promotes an early transition from concrete to formal thought. It is based on Piagetian theory and consists of three phases, exploration, invention and discovery. This technique emphasizes the role of experience in the learning process[7] since students are involved in concrete experience with materials or experimental data in the first phase and this may be retaken in the third phase in order to generalize concepts that were introduced in the invention to interpret and explain the experimental results. Self regulation is then completed and the appropriate mental structures are developed or reinforced.

IV. ACTIVITIES

Considering the problem of savings and resources we have developed activities, meeting this methodology and shortly described below.

A. "Power from water"

Students are asked to light on a lamp using a power generator consisting of a rotating magnet. The rotation is produced by circulating water, in a first step tap water and later water from a reservoir of convenient size. The first situation is used to illustrate the principle of hydroelectric sources and the second, the evidence no water no power. A discussion is conducted in terms of geographic location, advantages and limitations which conditions the use of this renewable source. Also, refering to the second situation the importance of saving is emphasized.

In the third stage it is shown that production of energy can be attained using agents other than water to promote the rotation of the magnet. Namely, wind, steam from burning coal, etc. Students are also asked to calculate the wattage of light bulbs in the classroom, estimate daily and annual use and cost. Saving strategies are analyzed in terms of annual costs.

B. "Boiling eggs"

Students have to boil eggs using the following heat sources, an electric plate, an alcohol lamp and a "sun stove". As soon as the eggs in the two first cases are cooked they start to estimate the required wattage, amount of alcohol and costs per boiling egg. Also, considering that students use to eat an egg every day, they have to calculate the costs corresponding to each of the cases. Finally, the topic is generalized to further applications of the energetic potentials of solar energy namely conversion to electric energy and photosynthesis.

In both activities students are organized in groups since peer interaction enhances a meaningful learning process.

V. CONCLUSION

Two tests, a diagnotic prior to the activity and another carried out after, demonstrate changes in mental structures both at cognitive level and in attitudes. Mental structures are, in essence, adaptive, so that the organism can successfully interfere with the environment. Confronted with energy situations, students become more aware of shortage, savings, comparative advantages of several energy resources and also, of the importance of developing new ones.

FOOTNOTES

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29.2

THE SOLAR ENERGY CURRICULUM PROJECT

by

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1.0 INTRODUCTION

The lack of public knowledge regarding solar energy has proven to be a serious deterrent to its successful commercialization. Recognizing both the short term benefits of informing teachers, parents, and other community members about solar energy and the long term benefits of teaching children, the U.S. Department of Energy (DOE) has sponsored the development of elementary and secondary school solar energy curriculums. This paper discusses the development of the secondary school curriculum and DOE's efforts to disseminate the curriculum working with four Regional Solar Energy Centers (RSECs) and state governments. As an example, Florida's methods to adapt the solar materials local school districts' educational programs will be described. The knowledge and experience gained will be useful to educators developing school energy programs and to governments trying to accelerate the commercialization of solar energy.

2.0 CURRICULUM DEVELOPMENT

The seccondary school energy project was initiated in 1977 when DOE funded the New York State Education Department and the State University of New York Atmospheric Sciences Research Center to develop a solar energy science curriculum for grades 7-12. During the summer of 1977, 80 secondary school science teachers met with technical and education experts to begin writing solar energy lessons. First, the teachers decided to base the solar energy science curriculum on several pricipies:

- The solar energy activities should be integrated into existing science classes.
- The material should be presented in a straightforward, objective way giving the advantages and disadvantages of using solar energy.
- The materials called for in the experiments should be accessible, inexpensive, and simple.
- The curriculum should be activity oriented since students learn best by doing.

The resulting curriculum includes a Teacher's Guide, a Text containing background information on solar energy, a Reader consisting of articles reprinted from magazines and journals, and 43 classroom tested activities. The activities are suitable for infusion into five science curriculum areas: junior high science, earth science, biology, chemistry, and physics. Lessons include constructing a collector from a coffee can, measuring the insulating properties of different materials, designing a passive solar energy house, and exploring the opportunities for employment in solar energy occupations and related fields.

3.0 CURRICULUM DISSEMINATION

The solar energy science curriculum has been available for national distribution and field testing since March 1979. Copies have been distributed to such organizations as state energy and education departments, cooperative extension programs, vocational/ technical schools, environmental studies centers, and teacher education programs. During the 1979-80 school year, the curriculum was pilot tested by 357 teachers in 44 states. Based on the field test, the solar energy science curriculum is being revised. For example, additional lessons in wood burning, wind energy, and passive solar energy are being added. The Reader is being expanded and the text is being reformatted to include additional graphics. The final; revised edition of the solar energy science curriculum should be available by the 1981-82 school year.

Using the same curriculum development model, the solar energyy curriculum is being expanded to include lessons in vocational education and the humanities. Industrial arts and home economics teachers met last fall to being writing lessons. These activities are currently available for national pilot testing. The social studies and humanities activities will be distributed during the 1981-82 school year.

Since teachers are often reluctant to use new materials, especially those dealing with unfamiliar subject matter, our office is working with DOE's four Regional Solar Energy Centers to disseminate the curriculum through in-service training workshops. For example, during the summer of 1979, the North East Solar Energy Center (NESEC) conducted a workshop to train 30 teachers to disseminate the curriculum in the nine state NESEC region. During the 1979-80 school year, each of these teachers conducted at least two in-service training workshops to introduce the curriculum. By the end of the school year, approximately 3,000 teachers had attended the workshops. Similar projects are being planned by the other three Regional Solar Energy Centers.

4.0 CURRICULUM DEVELOPMENT IN FLORIDA

Florida had to approach the need for a solar energy project based on different needs. Because of state mandated pupil assessment tests, all disciplines are required to teach "basic skills". In many school districts, teachers are given assessment cards for each student and must indicate when each pupil masters a particular skill. These burdensome bookkeeping requirements leave little room to teach about solar energy.

Because of the inherent interest students seem to have in solar energy, Seminole County Schools in Sanford, Florida, decided to orient the solar energy secondary school curriculum to teach solar and basic skills. Middle school students (grades 6, 7, and 8) were targeted. Aided by a $9500 "mini-grant" from the Florida Office of Environmental Education, teams of math, language arts, science and social studies teachers/writers carefully reviewed the solar energy secondary school curriculum. Other solar energy materials were examined for their relevance to current objectives in their subject matter, potential student interest, and adaptability to Florida's pupil assessment program.

This multidisciplinary team met with consultants from the Florida Solar Energy Center, the Florida Department of Education and industry representatives. This workshop was designed to provide an overview of solar technologies, their uses in Florida and their potential for affecting the lives of students now and in the future. After the workshop, the writing began.

To enhance student interest in the materials and to unify the mutidisciplinary curriculum, teachers created a character, "Sunny Solar" and named the curriculum, SUNNY SIDE UP. Each discipline chose a format that would closely fit their existing textbook or student workbook. Instructional materials gleaned from other sources were modified to conform with the particular format. Prior to field testing, all the activities were reviewed by the consultant and the science/math supervisor for content. Each team reviewed every packet to reduce duplication, and more importantly, to provide additional ideas and exercises that would reinforce units from other disciplines. Math teachers wrote problems on the science units, language arts teachers added to the social studies units until each team had contributed to every other team's work.

To date, field testing has been limited by time. Project teacher/writers have tried the units in their classes and have asked colleagues to use them. Informal results indicate high student interest even among the poorer students and an excellent response from teachers both inside and outside the project.

The SUNNY SIDE UP curriculum now consists of four packets: language arts, science, social studies, and math. Each packet contains student directed materials for other disciplines. Packets will be revised during the summer of 1981 and distributed throughout Florida during teacher training workshops.

29.3

"ENERGY: A LOCAL CURRICULUM DEVELOPMENT PROJECT"

by

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For many years Liverpool Education Authority has been committed to introduce more science into the primary school curriculum. A number of schools participated in the training of materials from the national curriculum development projects. Nuffield Junior Science and the Schools Council Science 5 - 13, and subsequently formed a 'group system' in which teachers from schools in all areas of the city meet to discuss and share ideas. In the light of the standard of primary science work produced in schools and displayed in exhibitions and the interest and enthusiasm of teachers, it seemed opportune, in November 1977, to introduce more simple technology into these schools. 'Energy' was at that time being mentioned with increasing frequency by the media and was, clearly, a topic of national importance. The theme of 'Energy' suggested itself as a way of extending the primary science curriculum to include more technology and as a topic which would integrate many primary school activities.

Subsequently, a small working party of primary school teachers was established and, with their help, a booklet entitled "Energy - An Introductory Guide" was produced and distributed in October 1978 to a number of schools.

The introduction to this teachers' guide stressed that 'energy' is an abstract concept which we can probably best help develop in the minds of young children by providing 'concrete' experience of things which have this property. Brief summaries were given of the different types of energy and examples included of energy changes. The terms 'energy capital' and 'energy income' were introduced and background information supplied on a wide-range of energy sources. The ideas being developed using alternative sources of energy were described and suggestions given for simple investigations, by children, of such sources. The need to conserve our energy resources was outlined and experimental work suggested on, for example, the effectiveness of various insulators and ways in which the children could save energy at home and in school. It was felt that some teachers would wish to broaden their treatment of the topic to include historical and geographical aspects. Therefore, a section was included which briefly traced developments in the mining of coal, the uses of waterwheels and windmills, the demand for oil and gas, and the uses of electricity. Suggested activities for children's work included creative writing, consideration of consumer preferences, displays of the by-products of coal, exhibitions of electrical tools and map work on the distribution of coal, oil and natural gas fields around the world.

A major section within the guide was entitled 'Things to Make and Do', in which an extensive list of practical activities was suggested for classroom work. For example, within the area of electrical energy a start can be made by examining batteries and making simple circuits and can be followed by constructing electromagnets and model-making. The energy of candle flames could be investigated and steam power used to drive models. The scope for experimental work on 'sound' is wide and well documented. The effects of the sun could be observed with the production of shadows, rainbows, the melting of ice and the effects on plant growth. 'Energy' discovery tables and 'Energy News' noticeboards could be established in classrooms. People from outside the school—parents working on oil-rigs, deep sea divers, electricity and gas-board men—could be invited to give short talks about their work. Visits could be made to waterwheels, windmills and museums.

The emphasis was on teachers using this guide to develop their own units of work. It was felt that individual teachers could best decide which material was most appropriate to their children. In devising such units of work, it was suggested that the following objectives might be included:

a) a knowledge of some of the different forms of energy.

b) a knowledge that energy can be converted from one form to another.

c) a knowledge of the importance of food in providing energy for growth and movement in living things.

d) an awareness of the importance of the sun in providing our energy needs.

It was envisaged that scientific work on this theme would be integrated with other subjects, and provide much opportunity for the development of language and mathematical skills. This was confirmed in June 1979 when over sixty junior and infant schools participated in an Energy Exhibition held at the Liverpool Teachers' Centre.

The second phase of the project during the school year 1979-80 attempted to present children aged 5-11 years with a technological challenge which would exercise their imagination and ingenuity. The design brief presented to the children required the construction of a model which complied with one of the following specifications:

a) a 'vehicle' which is able to travel a distance of, at least, 2 metres on lands;

b) a 'vessel' which is able to travel on water;

c) a working model.

As the competition was a new venture the model specifications were kept as wide-ranging as possible. It was open to three age groups - infant schools, lower juniors (7-9 years) and upper juniors ((9-11 years). Models from junior school pupils had to be accompanied by a written report containing details of construction and testing.

The 450 entries for the final exhibition were of a high standard and showed that considerable thought, time and effort had gone into their creation. They were built using a variety of materials including balsa wood, washing-up liquid bottles, polystyrene, corks, Meccano, Lego; they were powered by small electric motors, stretched and twisted elastic, balloons and camphor. In a number of cases the models could be described as original; others demonstrated modifications and adaptations of existing designs. Examination of the written reports revealed how the models had been built, the kinds of materials used, the testing procedures, drawings of the various prototypes, the problems encountered and how they had been solved. The construction of these models allowed ample opportunity for discussions about 'stored energy'—in batteries, in twisted and stretched elastic, in the air inside balloons—and of how this enabled the models to move.

The final phase of this local project, in which classroom teachers have been involved in the development and implementation process, is to produce a more complete guide to the teaching of energy in primary schools incorporating teachers' feed-back and samples of children's work. This guide will then be available to a wider circle of teachers. The work produced indicates that 'Energy' is a relevant theme for inclusion in the primary school curriculum. Further, it is a 'vehicle' which allows teachers to pursue a diverse range of educational goals.

We are grateful for the support of the Schools Council (Morrell Fund) and The British Association for the Advancement of Science in this venture.

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29.4

Construction of an Instrument to Assess Effectiveness of Energy Education Programs

by

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The motivations behind energy education programs include (1) enrichment of cognitive content and (2) enhancement of values and attitudes judged desirable by designers of every education program and policy makers in general. Attention to values, attitudes, and even behavior change in the field of energy education seem to be typical when compared to other subject matters in the broader field of physics education. For example, the inclusion and treatment of energy conservation topics involve not only cognitive content but also a value, whether implicitly or explicitly presented in the texts. Thus, the task of constructing an evaluation instrument as adjunct of any energy education program implies a difficult first step of adequately and reliably sampling a content domain and a value domain.

The paper will discuss the results of two preliminary investigations:

(1) value-content analysis of some energy education texts and journal articles, and mass media advertisements; and

(2) cognitive content analysis of energy education texts and journal articles.

The results will be studied as they vary across identified target audiences in the formal as well as informal education systems, and as they group themselves into distinct types of classes for convenient translation into corresponding types or classes of items in any evaluation instrument.

29.5

A SOLAR OBSERVATORY AS BACKBONE FOR A HIGH SCHOOL ENERGY EDUCATION PROGRAM

by

Larry McGowan, Marlboro High School, Marboro, Mass. 01752

Our inexpensive solar observatory introduces students to solar physics, the mother of astrophysics, and provides an intellectural foundation for our energy education plans.

Monitoring solar variations and seeking solar-terrestrial relationships gives a realism to the study of the energy balance of the planet, as well as long range weather, climate and the causes of ice ages.

Study of the fusion reaction in the sun clarifies the relationship between geothermal energy, (sellar, not solar) nuclear reactors, and solar energy in all its forms.

The study of the solar spectrum illuminates not only much of physics but also the key processes of photsynthesis and the relation of fossil fuels to biomass.

Insolation investigations give meaning to the entire range of oceanographic energy storage. This leads naturally to an appreciation of the carbon dioxide greenhouse effect and long range anthropogenic influences on climate.

Study of the social and economic impact of solar variations (The "Little Ice Age", the "Year Without a Summer") forces the students to face the precariousness of our energy situation.

The students learn to base their energy values on solid physical evidence, and to sort their energy options in terms of long range effects as well as immediate gains. The influence on teachers may be even greater.

SESSION 30: ISSUES IN ENERGY EDUCATION

Marie Joost-Cox and Donald F. Kirwan
Office of Energy Education
University of Rhode Island
Kingston, RI, USA

During the five discussion sessions, a large number of issues were raised by the attendees. These were synthesized into the following need and issues statements and were reported to the participants at the conclusion of the conference.

1. There is a need for a credible and reliable network to gather and disseminate pedagogically sound and scientifically accurate resource materials to teachers and administrators.

2. Issues -

   How do we infuse politics and policy implications into energy topics?

   How should the development of classroom material be funded?

   Is there a need for an international professional association whose specific focus is energy education?

   How do we define what energy education means? Who is an energy educator?

   How can the effectiveness of energy education be demonstrated?

   How should energy concepts and technology be included in a voc/tech school's curriculum?

   Do we need to improve government and private cooperation?

   Considering the various national differences, how do we establish a world energy policy? A world energy education Policy?

   How do we determine the needs of students for energy education at the various formal educational levels?

   How do we identify the target groups which have special needs in energy education?

   How can various disciplines be united to attain energy education goals?

   How do we match energy education curriculum to cognitive development?

   How should teacher development and update programs be funded?

   Who makes the decision as to the energy mix to be emphasized in energy education?

   How do we determine whether an attitudinal or theoretical approach is better - Should we have both?

   How do we infuse the economics of energy into the curriculum?

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