An Energy Consumption Monitoring System

Massachusetts
Energy
Office

Conservation Extension Service

AN ENERGY CONSUMPTION MONITORING SYSTEM
FOR LARGE-SCALE ORGANIZATIONS:

Designed for and Implemented in the
State-owned Facilities of the Commonwealth of Massachusetts

ABSTRACT

To establish a successful Energy Management System, it is important to be able to qualify, identify, and monitor energy consumption. By implementing an Energy Consumption Monitoring System, an organization can target those areas which will benefit most from conservation efforts, and can also monitor the results of ongoing conservation programs.

This document is a guide for designing and implementing an Energy Consumption Monitoring System, with emphasis on the major characteristics of this applied information system. Throughout the discussion of various design alternatives, special consideration is given to the human element of the system.

The basis for much of the discussion in this guide is the work that was performed in designing and implementing an Energy Consumption Monitoring System for the Commonwealth of Massachusetts' state-owned facilities. A detailed explanation of the Commonwealth's system is given to exemplify this process.

ACKNOWLEDGMENTS

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OVERVIEW

The Commonwealth of Massachusetts currently spends over $50 million per year for energy consumed in state-owned buildings. Over the summer of 1977, a group of between 75 and 80 state facilities was identified and targeted for an intensive energy conservation program. This group consumes over 80% of the $50 million annual energy budget. In order to identify potential energy and cost savings and to evaluate the results of energy conservation projects, it was decided to monitor the energy consumption patterns of the targeted group of facilities. Prior efforts to collect energy consumption data and to implement a system for monitoring consumption patterns had been made; however, they resulted in incomplete, inaccurate, and unusable information.

Most of the prior efforts failed for a variety of reasons, the most common being that people were not properly taken into account in designing the system. This is a major shortcoming in this type of project, because a successful system requires close cooperation among many people and many departments in a state bureaucracy. The objective of this project, therefore, is to design and implement a complete and accurate computer-based man/machine system which balances human factors with "computer science," "systems engineering," and "operations research" approaches.

Over the course of this project it became quite apparent that several other groups were interested in developing a system for monitoring energy consumption in large organizations. There have been requests for information from thirty state energy office, the Department of Health, Education, and Welfare, two private consulting firms, and several local school systems. For this reason, this document has been prepared as a guide for designing and implementing an energy consumption system in a large organizational structure. It is intended that this guide be applicable, but not limited to, such organizations as state governments, departments of the federal government, large corporations with several companies, large companies with several facilities, management firms that operate several buildings, cities and towns, large school systems, and many more.

OVERVIEW

ENERGY CONSUMPTION MONITORING SYSTEM

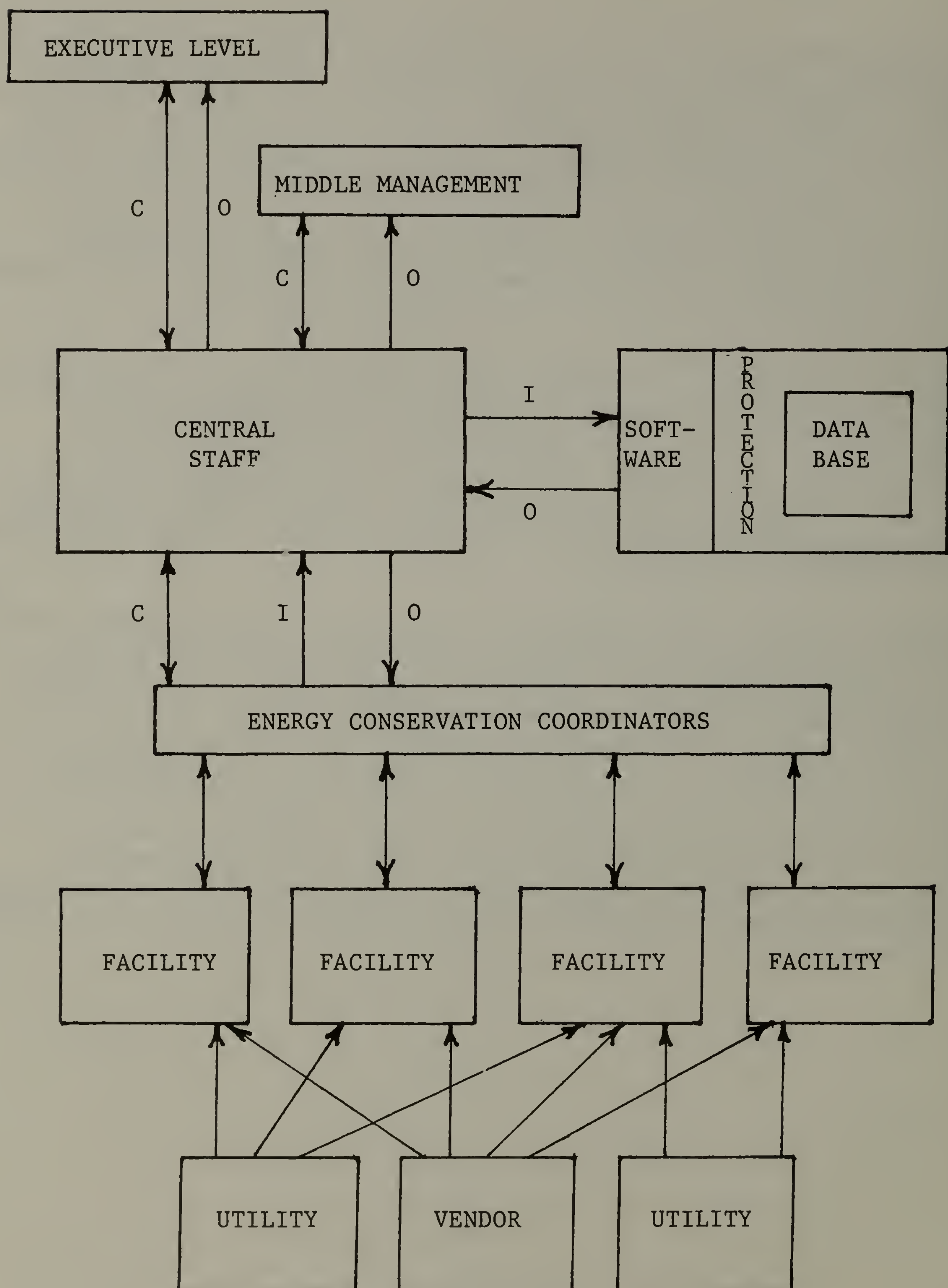

FIGURE 1

I: Input
O: Output
C: Communication

1. AN ENERGY CONSUMPTION MONITORING SYSTEM

A successful Energy Management System should be able to quantify, identify, and monitor energy consumption. By implementing an Energy Consumption Monitoring System (ECMS), an organization can target those areas which require energy conservation efforts, and can also monitor the results of on-going conservation programs.

The specific details of an ECMS will not be discussed in this chapter, since the details develop as a particular organization adapts the general concepts to its particular situation. The approach used here will be to begin with the most comprehensive viewpoint and move toward specialization.

Any discussion of system development necessarily begins with a definition of the term "system." From a manager's viewpoint, a system is a combination of people, equipment, and procedures ordered for the accomplishment of a unified purpose or objective. This discussion, however, is limited to one application of an information system to monitor energy consumption.

Information systems can be analyzed by consideration of eleven interrelated characteristics, which are: people, equipment, procedures, objectives, communication media, dynamics, data base, input, output, limitations, controls. This can be viewed as a system designer's checklist of elements to be incorporated into the design.

Stating the System's Objectives

Essential to every information system is a specific purpose or reason for existing, usually stated in the form of a set of objectives. In dealing with complex systems, it is necessary to state these objectives formally, clearly defining the specific results to be achieved. The more precisely the system's objectives are stated, the more effective will be their implementation. Conversely, the more vague the statement of objectives, the greater will be the number of assumptions made by the development staff and the less likely it will be that the system will truly work. Some of the possible benefits and objectives of an ECMS as part of an overall Energy Management System are:

* To provide the quantitative basis for an overall energy management program
* To assess which buildings or facilities or processes have the greatest potential for energy savings
* To monitor the results obtained from implementation of energy conservation measures
* To provide a basis for projections of energy use and cost for growth and budgeting purposes
* For industrial processes, to monitor production efficiency on the basis of energy consumption per unit produced
* For fleet management, to evaluate gas mileage and hence schedule tune-ups and maintenance accordingly
* To prevent overcharge in energy bills
* To measure progress towards goals set as part of an energy conservation program.

The importance of clearly defined system objectives cannot be overemphasized. All details of the developed system come out of what the designers perceive the objectives to be, and management has the responsibility to insure that the designers' perceptions are accurate. It may be the case that management is only partially aware of the potential uses of an ECMS, and therefore the stated objectives may reflect this lack of understanding. Management should invest the time necessary to discuss fully the capabilities of the system before establishing the set of objectives.

An example of such a problem is the failure of the system that preceded the current ECMS in Massachusetts. The New England Regional Commission (NERCOM) contracted to the M.I.T. Energy Lab to develop the New England Energy Management Information System (NEEMIS). As a part of NEEMIS, an energy consumption monitoring system was developed to monitor energy consumption in state facilities. This system was to be used by the six New England states. However, at the beginning of the development, the objectives of the system were not clearly defined. The system that was subsequently developed involved some very sophisticated and complex procedures and software programs; however, the data input methods and the output were not adequate to meet the user requirements. What resulted was a complex ECMS that is not being used with any degree of success by any of the six New England states. There are several reasons why the NEEMIS ECMS has not been used, some of which will be addressed in other sections. In the final analysis, however, it neither met the requirements nor fulfilled the objectives of the New England states for monitoring energy consumption in state facilities.

Development of the System's Input

Associated with the development of input to the ECMS is the consideration of procedures, communication media, dynamics, and, to some extent, limitations and control. All of these aspects are involved in setting up the channel of information from the energy-consuming areas to the area of data storage.

The term "input" refers to more than the specific items of data fed to a computer; it includes all information relevant to the system that originates in the external world. This includes information in non-standard form such as verbal. The input process involves the coding and/or formatting of such information for recognition and response by the system.

To obtain accurate and complete information as input, procedures must be established to deal with both routine and non-routine (but anticipated) occurrences that complicate the input data acquisition process. These procedures could be incorporated into either the programming or the standard operating procedures for the people dealing with the input.

It is important that implemented input options not lack the ability to withstand and adapt to planned or predicted changes in environment or internal conditions and functions. The term "dynamic" refers to the ability of a system to alter itself or to be altered readily in response to these changes. Requirements for system revision may be environmental (resulting from changes in population size, bureaucratic relations, or political attitudes) or internal, reflecting the setting of new objectives, management decisions, changes in personnel, and so on.

2. SYSTEM INPUT AND DATA COLLECTION ALTERNATIVES

In planning an efficient and reliable data input system, the designer should focus on two primary concerns: the ultimate source of the data and the human factors involved in getting these data into a form which can be transmitted to the system.

Input Alternatives

The type of input system that is designed for any particular information system will depend on the organization from which this information is extracted. For example, collecting information for an organization in which the desired data have never before been accumulated on a regular basis will require a different type of input system than one in which the desired data are readily accessible and may be already computerized.

There are actually several factors which will determine the final form of a data input system applicable to a given organization. Four of the factors that are particularly important are: (1) the type of organization; (2) the geographical centralization of the organization; (3) the knowledge and expertise of the people who supply the data; and (4) the resources available to carry out this project. To take into consideration these factors and any others which are important, the designer must examine the input alternatives that are available. This is particularly important since the design and subsequent success or failure of the system input process will play a large part in the overall success or failure of the energy consumption monitoring system. The next sections discuss several of the alternatives that should be examined in the design of a system.

Information - Desired vs. Available

The information desired as output in an ECMS determines the information required as input. One problem that is frequently encountered is that the required input data to meet the output objectives is not properly identified beforehand, or may be identified but cannot be collected. This problem can generally be avoided at the design stage by proper identification of the data elements that are required.

The system designer must determine the types of output information that are required or may be required in the future. The list should be as comprehensive and far-sighted as possible to insure that the ECMS will not be unduly limited in the future. Once the list of output requirements is compiled, it is relatively straightforward to identify the specific data elements that will be required as input.

The data elements must be specified as precisely as possible. The list should include any other data items that are potentially beneficial in evaluating other energy-related activities. In other words, this list of detailed specific data elements could be considered a "wish list" for quantitative input to the overall energy management system.

The next step requires that the designer be realistic in determining exactly which data elements are absolutely essential to the success of the system. He/she should determine the absolute minimum of output information that is required to meet the overall system objectives. This required output determines the minimum data elements required as system input. The ultimate wish list should differentiate between mandatory minimum input and other helpful but not mandatory input data. This list can now be used as the base on which the details of the input system can be built.

Sources - Vendors vs. Users

With the list of desired input elements in hand, the next step is to identify the potential sources from which these data can be extracted. In a broad sense, there are two sources for much of the energy consumption data: (1) from within the organization, or (2) from energy vendors who supply the needs of the organization. In most cases it is most appropriate to collect the data from within the organization, although there are certain cases for which it is sufficient to collect a large portion of the energy consumption data from the energy vendors.

It is most desirable to collect energy conservation data from such sources as electric and natural gas companies or from fuel oil vendors when one or both of the two following cases apply:

1. The organization is in a relatively small geographical area where there are very few vendors who service most energy needs. An example would be a school system with 20 or 30 buildings served by the same local vendors. In this situation data could be collected from a centralized source (3 or 4 vendors) rather than from each individual school.

2. Several large users are serviced by a very limited number of vendors. There may be a large number of entities to be monitored or a relatively large area that is served by a very few vendors. For example, in Puerto Rico there is only one major supplier of electrical power, no natural gas, and a limited number of oil vendors. A similar condition exists in the State of Maine.

Although there are some advantages to obtaining the input data from vendors, there are also some problems which must be weighed. First, it is likely that not all of the required input data can be obtained from the vendors. Certain other data elements such as building square footage, miles traveled, production rates, or other appropriate indicators must be collected from other sources. In some cases this information may have to come from the same people from within the organization who would supply the consumption data. Another problem might be in the human element. The responsible consumer in the organization (building superintendents, chief engineers, etc.) may be somewhat uncooperative or offended by a report telling them how they are doing when they have no input into the system. This may make them feel policed rather than involved in an energy conservation effort.

The other source of the required input data is from within the organization. Here, data may be collected from one centralized department which handles all bills for energy-related consumables, or they may be collected by a responsible individual in direct contact with the monitored facilities.

Because the first method often leads to the problems discussed above, the second method is preferred. Data may be collected by a building superintendent, a Director of Physical Plant, or a company energy conservation coordinator. This person then becomes a source not only for consumption data but for all other required data elements as well, and can compile these data from appropriate local sources.

This method of data collection has two advantages. First, it allows greater control over the data input process, and second, it involves people from within the organization. This method, if handled properly, will add to the probability of success of the ECMS.

Data Collection

Once the data source has been established, the next concern is how to get the data from their source to the ECMS data base. The two most obvious methods involve either entry of the data directly into the computer via a terminal or other type of interface, or submission of the data on some type of form to be processed by the central staff. For either of these methods, a form is needed to collect and summarize the data elements. For interactive computer entry, the person must first collect all of the data before entering it into the computer. For the other case, a more detailed form may be needed to facilitate processing of the data once it is received by the central staff.

Special consideration must be given to the design of the form and the accompanying instructions. As a minimum, the following considerations should be included in the design of the package:

1. The form and instructions should be designed to enhance the probability of the user's supplying reliable and valid data.

2. The form should be as visually clear, simple, and unalarming as possible. The most important instructions should appear on the actual form rather than as an attachment.

3. The detailed instructions that accompany the form should be as explicit as possible. The instructions should anticipate and attempt to avoid any potential confusion or problems that the user might encounter.

4. If there is a universal source within the organization for certain data items, this source should be identifed in the form.

5. If the data on the form is later to be keypunched, the entry spaces should be set up to separate each individual character in a data element.

6. The units of the desired quantities should be clearly marked and emphasized. One of the common problems will be reporting of a quantity in the wrong units.

7. Due dates and submission procedures should be clearly specified on the form and emphasized in the instructions.

8. If the actual form is to be submitted, the name and phone number of the person responsible for filling out the form should be included. This is an added incentive for that individual to insure that the data on the form are complete and correct.

An example of a simple collection form and instructions is attached in the Appendix. Some applications of an ECMS may require a more extensive data input form. One such form encountered involved collecting over 60 data elements on a monthly basis. To reduce the potential for errors, any package should be given a trial run before implementation. This enables designers to identify and correct problems before the package is implemented throughout the system.

For applications using some form of interactive computer input, both the appropriate computer software and hardware links and procedures will have to be developed. One option is to develop a program which is executed by the person inputting the data. The program asks the person the appropriate series of questions, giving instructions for each. The person inputting the data would only be required to enter each data element from the already completed form as the program asks for it. On the computer end, the data could be run through a series of validation checks (next section), simply stored in a file for central staff processing, or entered directly into the data base. If the latter is the choice, every effort should be made to insure against unwanted access to the data base by the user. The barriers between the user and the actual data base must be impermeable.

The other data collection system is best applied to vendor submission of consumption data. In most cases, large vendors will have their records automated enough to supply the required data in a machine-readable format, most likely on magnetic tapes or punch cards. This alleviates many of the problems involved with the collection system; however, one additional problem is encountered. In order for the data to be of use in the ECMS it must conform to the format required by the defined data base organization. The data must also be identifiable. Thus there must be some processing of the data to correlate vendor identification with ECMS identification in addition to any reformatting that will be required.

Data Validation

No matter how well the input system is designed, there are people involved, and people make mistakes. Many of these mistakes can be avoided through proper consideration and design; however, a validation process is necessary to enhance the credibility of the data that are entered into the data base. For a collection system employing automated input procedures, the data validation should be done as part of the input process. If a data element is not judged valid by the checking routine, it can be given back to the person inputting it with a request that the data item be re-entered.

If the collection system involves submission of the data on a form, much of the validation can be done before the forms are processed into the computer. By manually checking over the forms, a large percentage of the data errors can be spotted and corrected before additional processing. This not only maintains central staff contact with the data input problems, but it also prevents additional errors made by keypunchers who attempt to interpret unfamiliar data.

The most common types of validation checks to be performed will include checks for completeness of all data elements, unit costs for fuel, magnitude checks on level of consumption, etc. The two most frequent problems will most likely be incompleteness of data and fuel quantities that are reported in the wrong units (mcf vs. ccf, or barrels vs. gallons). Although these simple checks cannot insure total complete accuracy of the input data, they will provide the system with a highly reliable, valid data base.

Reporting Problems

Since an energy consumption monitoring system is an ongoing application of an information system, the added dimension of time, and the three problems that dimension entails, must be considered in the ECMS design.

First, it must be determined how often the input data is to be collected. This decision should be based on the requirements for system output in addition to the periodicity of data sources. In cases where the consumption data is extracted from monthly billings, a monthly cycle may be the most appropriate.

Second, some standard reporting time must be established to insure systematic submission of the input data. The problem here is that different fuel types generally have different billing periods. Thus, unless the reporting period for each fuel type is recorded, there will be some difference between the established reporting period and the actual billing period. One method that is sometimes accepted is to set the reporting period from the first through the last day of the month, with any billing period ending in that month being considered as the consumption for that month. For fuel oils, consideration must also be given to deliveries versus actual consumption.

The third problem is the lag time between the end of the reporting period and the time the data is reported and processed. Every effort should be made to minimize this lag time in order to provide responsive output back to the users promptly enough to be useful.

Organizational Factors

By considering the possible alternatives above, an appropriate combination can be formulated to meet the needs of the organization. The type of organizational structure and the human factors involved also need to be taken into account. It is important to consider whether or not implementation of the ECMS input process will disrupt any existing systems. If so, it is likely that the implementation of the input collection system could run into severe problems. In some cases, lower level groups may already have a form of consumption monitoring that is being used, possibly on a daily basis, to monitor operation of a building or plant. When implementing the ECMS, special care must be taken not to disrupt existing efforts. In fact, existing efforts may serve as a tool for learning how to improve the potential performance of the ECMS on the larger scale.

Implementation

Successful implementation of the data input system relies very heavily on human factors. While these factors will be discussed in detail in the following chapter, it is essential here to recognize the importance of clearly delineating the roles and responsibilities of the several groups involved; of determining clear lines of authority; and of establishing set procedures and smooth human communications systems.

3. HUMAN FACTORS

The key element in implementing a successful ECMS is having the support and cooperation of all the relevant individuals and groups within the organization itself. One of the basic reasons for a system to work poorly or not at all is a failure by the designer to consider all of the human factors that affect its performance. This chapter presents some of the considerations in this area.

One psychological factor to consider is that many people have negative attitudes toward computers. These attitudes will be reinforced if the new system is experienced as inefficient, impersonal, or inflexible. Therefore, in addition to providing a good technical design, it is important to personalize the system communication lines as much as possible. This includes involving people wherever possible rather than automating the process, and taking care to personalize the message that the computer generates. The designer must also consider which people at what level will require the system and be required by it. For example, who will be gathering the consumption data at the facility, who will be submitting the reports, who will receive summary reports, who will be reading the data and checking its accuracy? This will determine the simplicity of the language and the level of analysis of the data.

The designer should also consider the core staff requirements. Once the information is submitted to the field, someone must receive it, process it, analyze it, and make it available to users. Since these are usually new positions, they can be selectively tailored to the needs of the ECMS designer.

Another "people" problem to be considered here is what John Gall has referred to as "hirelings hypnosis," a trancelike state or suspension of normal mental activity which is induced by membership within a system. This tendency is most likely to occur with excessive routine in the production aspects of the system. While there must be enough routine to avoid crisis management, designers should avoid excess. The following is an example of "hirelings hypnosis": "A large private medical clinic and hospital installed a computer billing system. One day the system printed out a bill for exactly $111.11 for every one of the more than 50,000 persons who had attended the clinic during the preceding year ... The person operating the computer system that day, as well as the office clerks, the programmer, and the twelve employees employed to stuff, seal and stamp envelopes all had observed the bills but had done nothing to stop the error. The system had hypnotized them!" In short, people see mistakes and let them happen. The designer must point out to the members what the limitations of the data are. He must make certain his core staff do not blindly accept obvious errors in data from the field. And, he must set up the system in such a way that it checks its own information.

These are a few of the particular human factors to consider in setting up a consumption monitoring system. The precise list must be determined by the designer.

Interfacing with the Existing Organizations

In considering the human factors in devising an ECMS within a large organization, it is important to look at the roles and responsibilities of various groups and at the relationship between them.

A system designer must consider, at the outset, which people and which groups will be required to support the goals and operation of the system. He or she should bear in mind that most people already have many demands on their time, and many not take kindly to additional work. Identifying the appropriate individuals and groups is the first step in developing the broad base of support necessary for a successful system. The designer should also recognize the hierarchy involved, starting at the top of the chain of authority and involving people on down the organizational ladder.

Corporate organizational structures are usually well defined, making it simple to see where to start. Often, a simple "yes" by the right person is enough to insure that the system will be implemented. It is desirable, however, to develop broader support of the project. People are much more inclined to perform well in a system if they feel they have contributed to the system design.

Bureaucratic organizational structures are much more difficult to assess. The lines of authority are very blurred. Often there are people whose titles and responsibilities do not reflect their actual roles in the bureaucracy. Their importance in implementing the system cannot always be determined by an organizational chart. The designer's problems are further complicated by persons whose responsibilities cut across many organizational lines. These people, while having no desire to be involved with the working system, can sabotage the system construction unless they are approached and consulted. A designer must also consider that there is no <u>single</u> bureaucracy in any governmental organization; there are a series of bureaucracies. Many are independent or semi-independent. They will rarely have the same structure. Because of these complexities, a greater number of people must be contacted at the outset, and the numbers will expand as the system becomes operational. Failure to analyze the bureaucratic organizations involved, and the resultant failure to make contacts for broad base support of a new system, will result in reduced effectiveness of the system.

Project Task Force

One good way to obtain cross-sectional support for a new energy consumption monitoring system is to set up a project task force. The size of the task force is the result of a trade-off between (1) having all organizations within the bureaucracy well-represented and (2) having the smallest possible task force to improve performance. The members will have responsibility for energy consumption by the people under them in the hierarchical structure, and thus will take an interest in the design of the system.

For the Massachusetts Energy Consumption Monitoring System, departmental ECC's (Energy Conservation Coordinators) were chosen for the task force. These persons generally held positions as Directors of Engineering Services for an entire department. By coordinating the system implementation through a total of 9 ECC's, 75 facilities were represented. These facilities represent over 80% of the total energy consumption for the state. The remaining 20% of energy consumption facilities did not have so easy a route for representation. It was decided to disregard this latter group until the system was operational, and then to incorporate them as they expressed desire or the system became capable of handling their needs.

Other expertise was added to the task force which did not represent a particular facility or energy consumer. Specifically, a member of Administration & Finance was added and a member from the Bureau of Building Construction. Their purpose was to lend credibility to the system. Since their responsibility pertains to paying for energy, paying for improvements, and managing improvements to the facility, it was felt that their presence would facilitate the implementation of changes at each facility to help to reduce energy costs.

Another expert who is desirable on a task force is a data processing manager. This person's experience can be extremely helpful in determining the exact EDP requirements for meeting the ECMS objectives.

Though facility managers were not selected as members of the Massachusetts task force, it was considered important to obtain their input. The task force members contacted each facility manager individually for his/her opinions regarding the real world problems the system might encounter. Thus, user support was encouraged by obtaining user participation from the beginning. All the members were given the opportunity to acclimate themselves to the efforts they would be required to expend in the care and feeding of the system.

In general, the task force members provide a conduit to the top level management personnel in the department and the facility. These persons eventually establish the authority base behind the system even though they are not actually involved in the operation of the system.

Central Staff

The requirements for people to manage the system are greatest during the start-up phase. The central staff must be flexible enough to coordinate not only the production of the system (data collection, validation, and distribution, etc.) but they must be able to respond to unanticipated needs in the system. They should have the capability to respond to user contacts, i.e., they should think their language. During implementation, the core staff is often called upon to interpret the data analysis for the user, explain the system's complexities, and otherwise troubleshoot the communications lines. The central staff should be thoroughly prepared to handle communications from other members of the project. They should acknowledge and encourage feedback. They should develop the ability to consider problems from the other's point-of-view. Whenever possible, they should immediately solve the user's problems and furnish information. The staff can help demystify the data and explain the uncertainties and possible errors hidden in the reports. For example, if a trend towards increased consumption is noted at a particular facility, the staff should help the user decipher the cause of the increase. It might be a more severe winter or an expansion in square footage at the facility. Failure to respond properly to an individual problem will erode confidence in the effectiveness of energy consumption monitoring.

Working Relations

The roles and responsibilities of the various groups must be clearly delineated. As suggested before, the task force should be used to gain a high organizational level of support. Since authority for lower level users rests with the higher level task force participants, this organizational line authority can be effectively used in implementing and initiating the reporting system. By discussing the reporting procedures, due dates and deadlines, and by obtaining the support of the members of the task force, they will then be instilled with a sense of responsibility and motivated to carry out the planned implementation. For large numbers of reporting entities, it is also wise to channel the incoming forms through the line organization to the task force members, then to the central staff. This gives the task force members responsibility for the practices of "my people." In addition, it will also lower the number of people that the central staff will be dealing with on a regular basis, thus improving the manageability of the system.

Once the data forms have been submitted to the central staff, they must be handled in a timely and efficient manner. They must be checked for completeness and manually verified; then they must be processed into machine-readable form. After the data is in the computer, it can be run through the automated validation routines, then entered into the data base, ready for compilation of the output information.

These procedures should be as systematic as possible to insure a timely response in the form of output back to the users. There is also a need for central staff procedures for handling questions and problems that the users of the system may have.

4. APPLICATION PROGRAMMING AND OUTPUT ALTERNATIVES

The well-defined objectives of a proposed energy consumption monitoring system determine the development of output procedures. Output requirements will generally fall into two broad categories: 1. Routine Reports. These can be relatively standard in format and frequency of generation. They require little human effort, since a software program has been developed to produce them. 2. One-of-a-kind reports. These require interactive use of the data base to produce specific types of output reports. They require significantly more human interaction with the data base in addition to flexible software which allows the user to query the data base in different ways.

Since the "one-of-a-kind" reports cannot be defined, they will not be discussed in detail; however, the software required to compile them will be discussed later. The next section focuses on the routine output requirements.

Routine Output Reporting Procedures

Four groups within an organization receive routine output reports. They are:

1. Working level
2. Middle management
3. Exective
4. Central staff

Because each level has different needs and requires different data, each receives a different report.

Working Level Reports

Primary emphasis should be placed on providing feedback information to the working level users who are supplying information to the system. This encourages future cooperation by showing the supplier that the data are being put to good use and by providing helpful information in return for the input data. It also provides a means for the user to check the information that was submitted, thus adding another type of data validation.

To meet these requirements, working level reports should generally be compiled with the same frequency with which the system input data is received. These reports should contain enough information so the user can assess the relative progress of his/her individual energy conservation efforts and might contain some information on the organization as a whole. The information should be detailed enough so the user can verify it, yet not so detailed that the volume of information is burdendome.

Middle Level Reports

The purpose of the middle level reports is to provide summarized information for a number of facilities in such a way that it can be useful in identifying and comparing their relative energy consumption levels. This is the type of report that would most likely be used by middle managers such as department ECC's, regional ECC's, or company ECC's, depending on the type of organizational structure. Since the middle manager would be in charge of several facilities, the information in the report should be summarized to the facility level, for easy comparison on a facility-by-facility basis. This type of information will allow the middle manager to identify the relative success or failure of conservation efforts in those facilities in order to take appropriate steps to implement better energy management throughout that particular group of facilities. In essence, these reports should provide the middle manager with the tools to implement the top level energy policy at the working level of the facility people. It many not be necessary to compile these reports with the same frequency as the working level reports; preparing them on a quarterly basis or even semi-annually may be adequate.

Executive Summary Reports

These reports provide top level management with a concise presentation of the energy-related information needed to assess past performance and to formulate policy regarding future energy-related activities.

These reports often lend themselves to a standard format generated by a software program. They are generally used to highlight certain decisions that are desired by the energy management team. Therefore, it may be desirable to compile an information sheet to extract the desired information and then to prepare a written report to present the language and format in the desired context while still making full use of the summary information compiled by the summary report software.

Special care must be taken to insure that the information is presented in the most clear and concise way possible. Top level management may not fully understand the intricate details of the information; yet based on the summary reports, they will make the decisions that will establish future energy-related reports.

Central Staff

There are also central staff requirements for output that must be met and/or udpdated on a periodic basis. Specialized reports for the central staff should include a status report on the completeness of the data base. This report will allow the central staff to monitor the status of the data base and provide the necessary follow-up to insure that the data are complete and valid. It is also necessary that the central staff maintain output information in varying levels of detail in order to monitor the input data and the energy conservation projects. In many cases, these central staff "information sheets" can be generated as a by-product of one of the other periodic output reports.

Data Presentation Techniques

In order to obtain the desired information as output from the system, the designer must first determine what the desired information is and how it will be presented. The following two sections discuss the interpretation of raw data and examine several alternate ways of presenting the output information once it is compiled.

Standardization of Raw Energy Data

In the system input part of the ECMS, the designer chooses what energy and energy-related data must be collected to generate the necessary output to meet the overall objectives of the system. The designer must also consider how the raw data will be interpreted and compiled to obtain the desired output.

There are several means for interpreting the raw data. The first decision deals with establishing common units for reporting energy quantities. Since the ECMS input includes several energy sources described in different units, it is necessary to convert these quantities to the common unit of BTU's or some multiple thereof. Two common conversion schemes are used that have different conversion factors for electricity: 1) the end-use value of 3411 BTU/KWH; or 2) the source value of approximately 10,500 BTU/KWH (the approximate energy input to the process of generating the electricity at the power plant). The first reflects what was consumed by the facility, while the latter reflects the cost to the region for consuming a kilowatt-hour of electricity.

Once the converstion factor has been decided and the consumption data is in common units, it is important to add certain indicators and comparisons to present the information in a more meaningful form. The indicators tend to normalize the consumption figures for various specific cases, thus allowing the specific case to be placed on a comparative basis. This can be particularly beneficial when comparing several different facilities in a department or when comparing the same facility from one year to the next. The list of common indicators in given below:

1. Thousand BTU's per square foot per year
2. Cost per square foot per year
3. Cost per million BTU's
4. Thousand BTU's per square foot per degree day
5. BTU's per unit produced (industry)
6. Miles per gallon (fleet management)

Several variations of these basic common indicators can be used. The following section illustrates a number of different methods for compiling and presenting consumption data for energy consumption in buildings.

Presentation of Information

The objective of any report is to convey information from one person or system to another. Since the output of an ECMS is quantitative in nature and since numbers tend to confuse a large number of people, special attention must be paid to the transcription of output information from the ECMS in the various output reports. The following illustrations are examples of the Commonwealth's formats for working level, middle management, and executive level reports.

FIGURE 2

MONTHLY ENERGY CONSUMPTION REPORT

JULY 1978

10101 STATE HOUSE

THIS REPORT GIVES INFORMATION ON ENERGY CONSUMPTION AT YOUR FACILITY. IT IS BASED ON THE 'ENERGY CONSUMPTION REPORTING FORMS' YOU HAVE SUBMITTED.

BELOW IS DATA FOR THIS JULY AND FOR JULY OF PREVIOUS YEARS.

MONTHLY USAGE			FY79	FY78	FY73
ELECTRICITY	KILOWATT HOURS		435600	434300	500440
	DOLLARS		28034	29364	13187
STEAM	KILO POUNDS		134	33	2608
	DOLLARS		1300	356	9195
TOTALS	MMBTU (SOURCE)		5127	4984	8994
	DOLLARS		29334	29720	22382
SQUARE FOOTAGE			500000	500000	500000
DEGREE DAYS FOR THIS MONTH:					
FOR YOUR FACILITY			237	0	***
WEATHER STATIONS		NORMS			
BOSTON		0	11	0	3
WORCESTER		6	33	16	16

FIGURE 2 (Continued)

THE INFORMATION BELOW IS THE CUMULATIVE TOTAL FOR JULY THROUGH JULY

YEAR-TO-DATE	FY79	FY78	FY73
ELECTRICITY THOUSAND KWH:	436	434	500
DOLLARS:	28034	29364	13187
OTHER FUELS MILLION BTUS:	170	42	3299
DOLLARS:	1300	356	9195
DEGREE DAYS:	237	0	***
ELECTRICITY KWH/SQFT:	.87	.87	1.00
OTHER FUELS 1000 BTU/SQFT:	0	0	7
TOTAL 1000 BTU/SQFT:	10	10	18
TOTAL COST/SQFT	.06	.06	.04

THE FIGURES BELOW REFER TO CHANGES BETWEEN THE TWO YEARS LISTED. A NEGATIVE NUMBER INDICATES AN IMPROVEMENT (DECREASE) IN CONSUMPTION.

PERCENT CHANGE	FY79/78	FY79/73
ELECTRICITY BTU/SQFT:	.3	-13.0
OTHER FUELS BTU/SQFT:	306.1	-94.9
TOTAL BTU/SQFT:	2.9	-43.0
DOLLARS/SQFT:	-1.3	31.1
COST/MILLION BTUS:	-4.0	129.9

FIGURE 3

BUREAU OF STATE BUILDINGS

ID#	FACILITY NAME	REPORTED SQ. FT.	FULL YEAR CONSUMPTION FY 73	FY 76	FY 78	PERCENT CHANGE 73 → 76	76 → 78	FY 78 MBTU/SQ.FT.
10104	Hurley Building	325,000	275,938	180,818	124,167	-34.5	-31.3	382
10102	McCormack Building	750,000	0	198,933	210,139	0	+ 5.6	280
10103	Saltonstall Building	325,000	255,640	155,121	163,778	-39.3	+ 5.5	218
10105	Lindemann Center	257,000	81,861	47,470	47,914	-42.0	+ 1.1	186
10101	State House	500,000	135,891	80,813	85,813	-40.5	+ 6.3	172
	TOTALS	2,582,000	749,300	663,065	631,811	-11.5	- 4.7	248

FIGURE 4

SUMMARY FOR 70 FACILITIES

ID#	FACILITY NAME	REPORTED SQ. FT.	FULL YEAR CONSUMPTION FY 73	FY 76	FY 78	PERCENT CHANGE 73 → 76	76 → 78	FY 78 MBTU/SQ.FT
401	Dept. of Mental Health	8,514,109	6,554,052	3,330,560	3,511,363	-50.8	+ 5.4	412
410	Soldiers' Home	644,908	237,993	201,546	226,104	-15.3	+12.2	351
404	Dept. of Corrections	2,997,292	920,374	982,643	1,029,484	+ 6.7	+ 4.7	343
500	Universities	15,177,756	3,156,975	4,651,178	5,144,645	+47.3	+10.6	339
402	Dept. of Public Health	4,046,928	1,707,484	1,112,314	1,150,857	-34.8	+ 3.4	284
101	Bureau of State Buildings	2,582,000	749,300	663,065	631,811	-11.5	- 4.7	284
506	Community Colleges	3,530,115	*	802,219	800,702	*	- .2	226
502	State Colleges	7,433,835	*	1,241,722	1,577,643	*	+27.0	212
	TOTALS	44,926,943	13,326,178	12,326,178	14,072,609	- 2.5	+ 8.4	313
	TOTAL COST		$13,139,706	$33,982,940	$39,943,122			
	COST PER MILLION BTUs		$.99	$2.62	$2.84			

Figure 2 is a sample of a monthly report which is mailed to the ECC's and all facilities. The first page is a compilation of the raw data for the current month and for the same month of past years. The second page compares the derived data for all fuel types, conversion into MBTU/sq. ft. and cost/sq. ft., and percent change between years.

Figure 3 is a middle level management report for a typical department. It gives the square footage for verification, energy consumption for three years, the changes between years, and the MBTU/sq. ft. index. This is presently compiled yearly, but could be done on a quarterly basis.

Figure 4 is the executive level summary for all facilities with complete data. Note that the format is the same as for the middle level report; this was done for the purpose of simplification but need not be the case. The information is the same as in Figure 3, but with departments reported as facilities.

Beyond these reports are the possibilities for graphical presentations. These could be plotted on an on-line terminal or a flat-bed plotter. The on-line approach yields much lower resolution but is substantially cheaper and easier to use. Below are four of the most useful types of energy consumption against time.

FIGURE 5 <u>Energy Consumption - FY75, FY76, FY77</u>

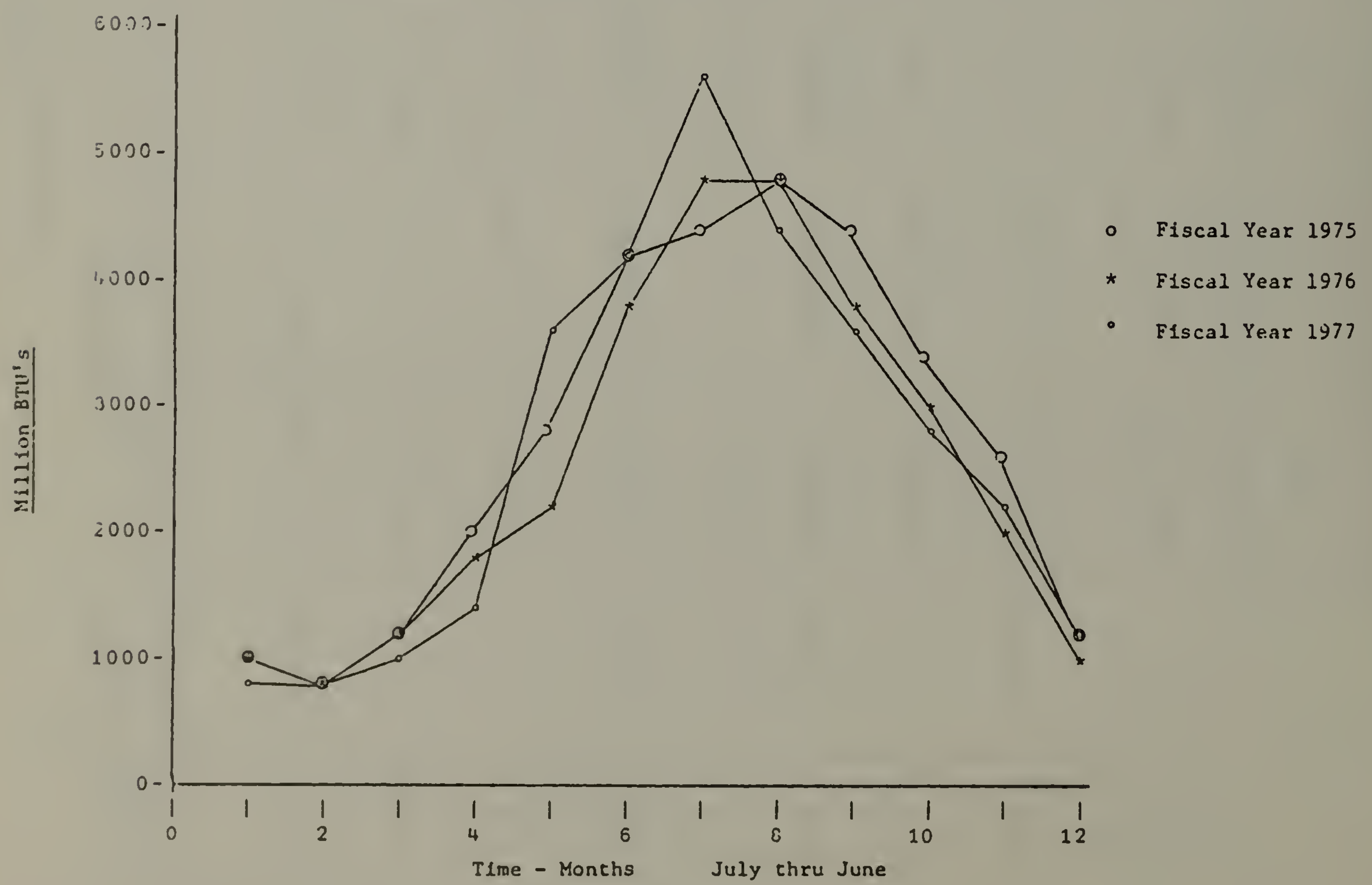

Figure 5 is the simplest useful comparison between years. It illustrates seasonal variations, is not adjusted for changes in square footage, and is not corrected for degree days. It does not allow quantitative comparison.

FIGURE 6 Energy Consumption per Square Foot

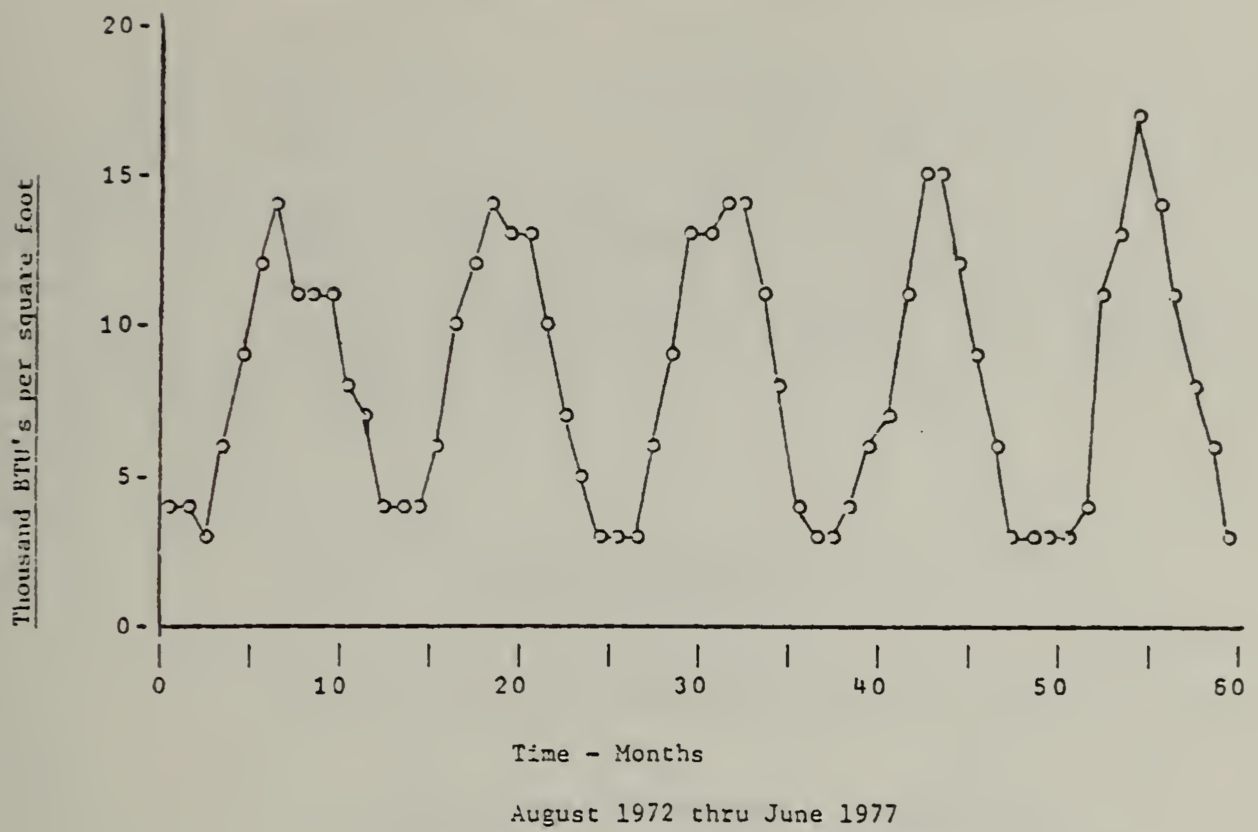

Figure 6 shows the MBTU/sq. ft. index against time. In this format it is difficult to interpret as it is not corrected for seasonal variations.

FIGURE 7 Energy Consumption per Square Foot per Degree Day - 12 Months' Cumulative

Figure 7 utilizes a 12 month cumulative total to normalize seasonal variations. The point for any given month is the total for the 12 months prior to and including that month. It is also corrected for changes in square footage and degree days, and is the most useful of the time histories. Note the decrease in consumption over the past three years.

FIGURE 8 Cost per Million BTU's

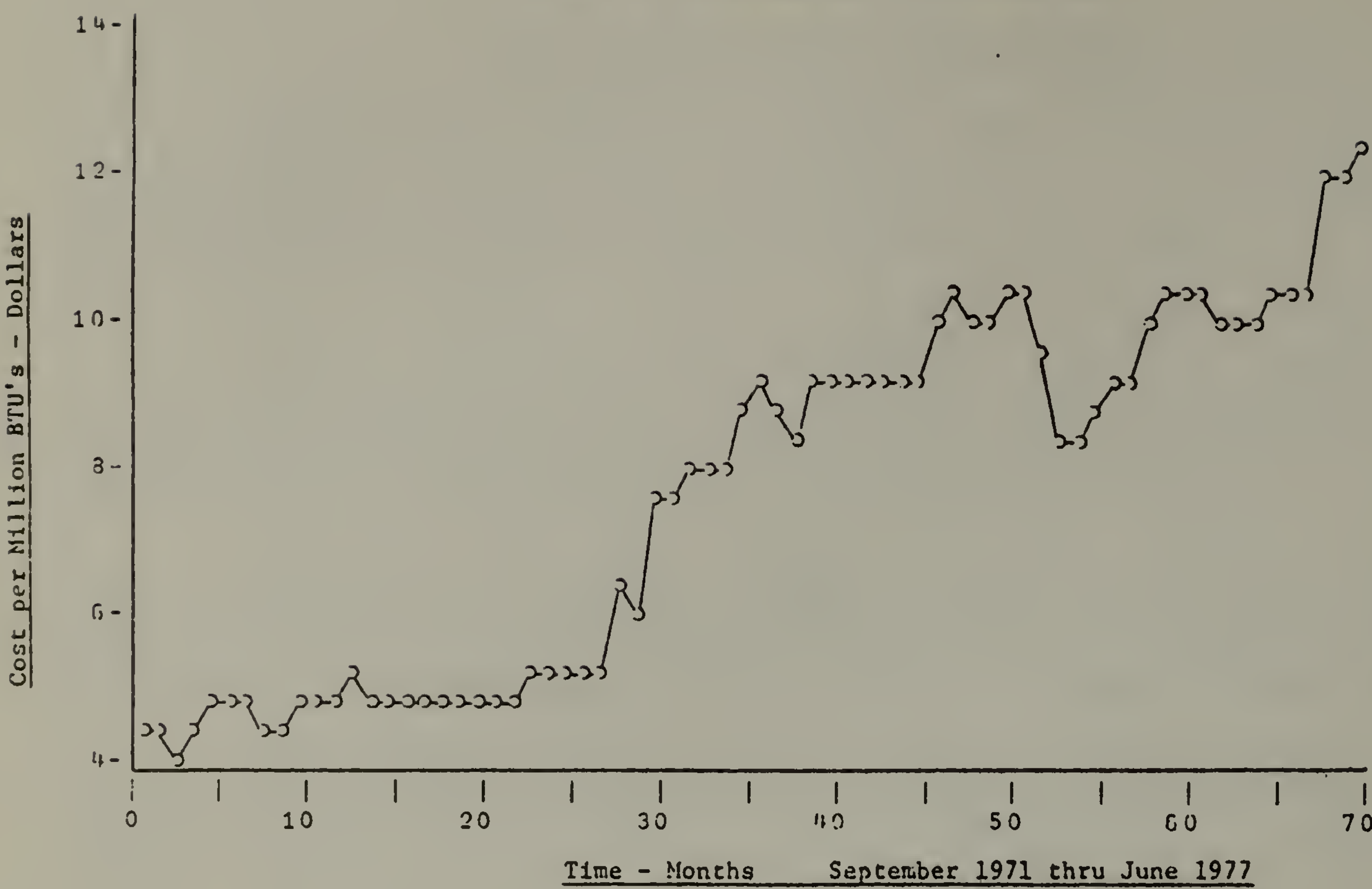

Figure 8 shows the cost per million end-use BTU's. Note the drastic increase during the oil embargo.

FIGURE 9 Consumption vs. Degree Days

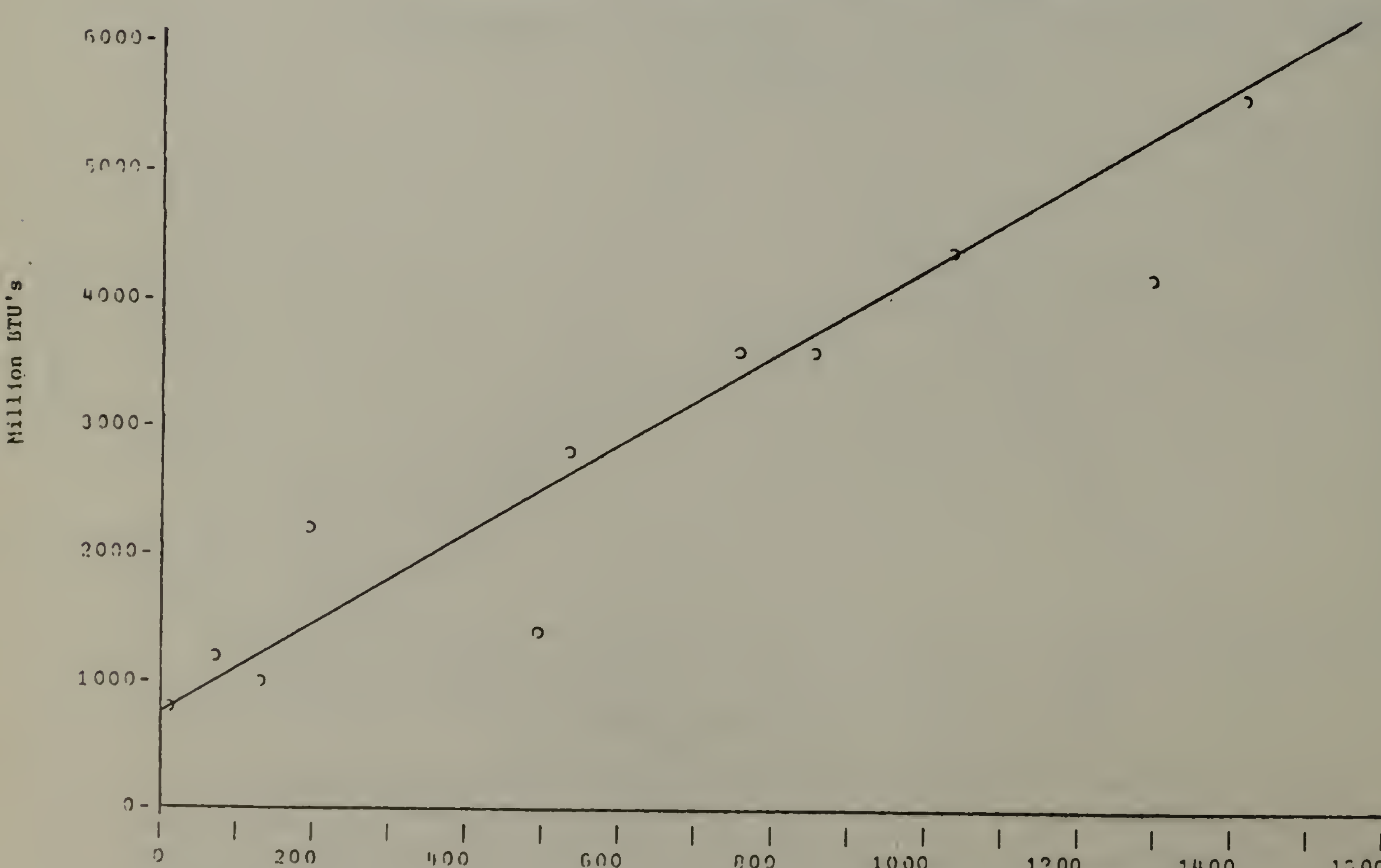

Figure 9 is probably the most useful for analyzing the operating characteristics of a facility. By plotting consumption vs. degree days, the base load can be determined, In addition, the slope of the line indicates the relative heating efficiency of the facility. Also the derivation of the individual months from the line is an indication of operating tightness and procedures. For example, on this plot, for the two months of October and December, the consumption is well below the norm. In December the buildings were closed down between Christmas and New Year's and in October the boilers were shut down for repairs.

FIGURE 10 Energy Consumption per Square Foot Per Year

FY 76

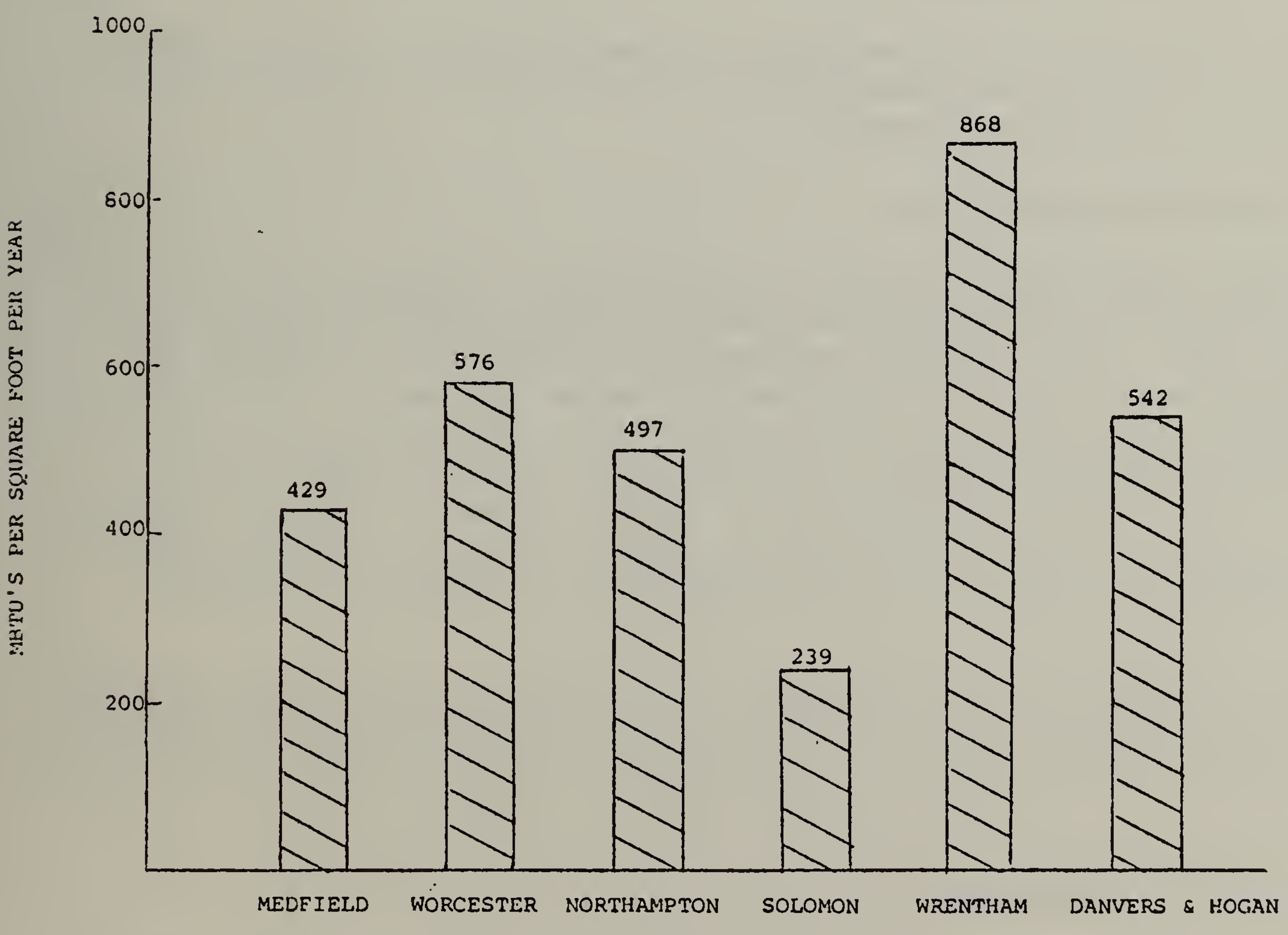

Figure 10 is a bar graph on consumption per square foot for six different facilities. This type of graph seems particularly applicable to the middle level type of summary report. This same basic concept could also be used for comparisons to the other indicators.

The preceding samples are not intended as an all-inclusive presentation of all applicable methods for graphic presentation. They merely suggest a few examples to spark the designer's thought processes. Probably the most important ideas to keep in mind when designing the presentation schemes are: (1) what information is to be conveyed, and (2) what will the audience understand?

Application of Programming Requirements

The degree of complexities and sophistication of the required software programs for an ECMS will depend largely on the type of data base organization and data base management system (DBMS) which is employed. The actual calculations required to compile the desired information are very simple; the only area that is somewhat cumbersome is getting the right information at the right place at the right time to perform the calculations. Rather than discussing the actual steps in doing that, it seems more appropriate to outline the general software requirements so the designer can prepare detailed specifications for the various software packages.

The two areas to be discussed are (1) the need for standardization; and (2) the need for sufficient flexibility to allow users to query the data and compile reports for unique requests.

Standardized Generation of Reports

The requirements for compiling a standard set of regular reports for the three different levels are nearly the same. It is most efficient to run them on a batch basis. The software packages must be general in nature to allow for expansion of the ECMS. They should also be designed to anticipate future requirements that may be placed on the system. The output should require a minimum of human processing prior to distribution, yet the output reports should not be blindly accepted without prior review. Thus, it may be desirable to build in "flags" to point out problems or noteworthy items in the output reports. The designer may want the information from a given set of reports to be summarized and listed for central staff use.

These are but a few of the software requirements needed for systematic generation of output reports. Since this is a production-type application, fine tuning is necessary to insure that the programs run as efficiently as possible.

Compiling One-of-a-kind Reports

The requirements for software for responding to unique requirements for information are quite different from those above. In order to respond to a specific request, the user will need flexibility in querying the data base to compile the required data. He must then be able to put these data into a presentable form.

This is the type of application that seems most appropriate for using data base organization and management. DBMS's have powerful query languages, and several have built-in report writers for handling unique requests for information. This seems particularly applicable for users who are not intimately familiar with the data base.

If it is necessary to proceed with development of a query routine for using the data in the data base, precautions should be taken to safeguard against a user's harming any of the data in the data base. The associated software should allow an unfamiliar user to extract data as easily as possible while prohibiting him/her from making any changes in the data base.

While this section is not intended to provide details of software design, it should enable the designer to define output requirements carefully enough to specify software needs.

5. MASSACHUSETTS ECMS DEVELOPMENT AND OPERATION

Over the past two years, the Massachusetts Energy Office (MEO) has undertaken an active energy conservation program within state-owned facilities of the Commonwealth. In addition to emphasizing no/low cost energy conservation efforts, MEO, in conjunction with the Executive Office of Administration and Finance (A&F), has set up a hierarchical chain of Energy Conservation Coordinators (ECC's) throughout the state organizational structure. This structure of ECC's serves as MEO's link to the energy conservation efforts at the individual facilities.

In order to quantify the results of energy conservation programs, in addition to coordinating the effort at the state level, it became desirable to develop an ECMS to assess the results of the energy conservation efforts. particular interest was the impact of the oil embargo on energy consumption, since New England is heavily dependent on imported oil; thus it was necessary to collect historical consumption data from a pre-embargo year. Fiscal year 1973 was chosen.

During this same period (early 1976), efforts were initiated by the NERCOM-funded NEEMIS project under development by the MIT Energy Lab to develop an ECMS that could be used by the six New England states. During the initial phases of the NEEMIS project, A&F attempted to collect data for fiscal years 1973 and 1976. This initial attempt to set up a reporting system to supply NEEMIS with the requested consumption data was unsuccessful. The forms used to collect the information from the ECC's were vague, and many incomplete forms were submitted. These problems were compounded in the keypunching process, where additional errors were introduced.

Somewhere about this time (mid-1976), the NEEMIS staff decided to develop a vendor-based reporting system for obtaining the desired consumption data. This method, too, resulted in incomplete and unmanageable data. In both cases, the problems seem to have arisen from an inadequate definition of user needs.

With this history, the MEO effort began in mid-1977. Because of the urgency of the problem, some compromises were made in the development process that have resulted in a less than optimal ECMS; yet what is in place does work, and it works well.

Assessment of Prior Efforts

Over the summer of 1977, contractual negotiations and other factors slowed development of the NEEMIS ECMS project. At this point MEO began to assess the NEEMIS ECMS, and determined that it was unlikely to meet the state's needs for monitoring energy consumption. The next step was to collect all useful information from the NEEMIS system, including the A&F-collected consumption data and some lessons learned by the NEEMIS staff.

During subsequent evaluation of these data, it was found that data had been submitted for many hundreds (if not a few thousand) of the state facilities and offices. To make the future efforts more manageable, it was necessary to screen out the facilities which consume relatively small amounts of energy. Through the use of accounting records from the state comptroller's office, MEO identified a group which consumes approximately 80% of the state's budget for energy expenditures. This group consists of the following types of facilities:

1. University campuses
2. State colleges
3. Community colleges
4. Public health hospitals
5. Mental health hospitals
6. Correctional institutions
7. State soldiers' home
8. State office buildings

This group of 75 facilities represented a very small percentage of the total number of state facilities, yet consumed a very large percentage of energy. In addition to this group, there were two or three "one-of-a-kind" facilities that might have been included; however, due to the added complexities they were not.

Once this target group of facilities was identified, the assessment of the historical data was somewhat easier. Of some 20,000 data records, only approximately 2,000 (or 10%) were for the target group. Of these 2,000 records, only approximately 60% appeared to be valid, with several identifiable errors that could be accounted for and corrected. These 2,000 records also only accounted for approximately 40% to 50% of the total number of consumption records needed for complete data. The data for FY76 were substantially more complete than for FY73, with the exception of May and June of 1976. The initial collection effort took place in April and May of 1976; thus the May and June data were not in existence at that time.

Since the original objectives included a pre-embargo/post-embargo comparison, it was still necessary to complete the consumption data for FY73 and FY76, as these years would provide the pre- and post-embargo base years for comparative purposes. The effort to complete the historical consumption data began in July 1977 and is still in progress. At present, the data is over 96% complete and valid for FY76 and FY73.

The initial efforts to complete the historical data proved to be a tremendous learning experience for identifying the types of problems and errors typically encountered. This knowledge was extremely beneficial in designing the input system for the on-going ECMS. The process that was used included: (1) going through the initial A&F forms to correct the data which had been misinterpreted during initial processing; (2) getting data from the appropriate department records when available; and (3) requesting additional data from the facilities. In many cases the consumption data for 2 and 5 years past was difficult to obtain due to poor record-keeping and because it was a time-consuming job for the facility.

Preliminary Design and Testing

In the course of this project, it became apparent that there was more than one course for obtaining the required consumption data. In addition to obtaining data from the facilities or vendors, information could be obtained from the state comptroller's office since all vendor-submitted bills are processed through that office. Another potential source is the Executive Office of Human Services. That office receives "Power House Reports" from the hospitals and prisons.

After careful consideration, it was decided that none of the existing sources could meet the ECMS needs. The power house reports did not include costs, and there was no equivalent report for the schools. The comptroller's office does not process the bills for the state and community colleges or the universities, since they have fiscal autonomy. The vendor reporting system, which was still operating in a small way, had the following problems:

1. Fuel oil vendors were contracted at the state level; thus a clause was included in the contract requiring data submission. However, there is a fairly high yearly turnover in fuel oil vendors supplying state facilities.

2. Public utilities were contracted for at the local facility; thus there was no contractual obligation to submit the data.

3. Vendors would have to be asked to submit data for only selected facilites.

4. Vendors have nothing to gain from their efforts, and therefore have little incentive to participate.

This led to the conclusion that the system should be based on information reported by the facilities themselves. By going with this alternative, indicators such as square footage and degree days could also be collected. Other advantages included: 1) improved channels of communication for ECC's; 2) increased potential control of the input process; 3) data collection by facility personnel which would serve as an instructional tool to increase awareness of energy consumption. Since input data would be submitted through the chain of ECC's to MEO, any outside requests for these data could also be channeled to MEO; thus the facilities personnel would probably not be plagued by multiple requests for the same information.

Design of System Input/Output

The design of the input system included everything from the structure and content of the forms to the motivational tools needed to generate a successful input system. Creating motivation was the main reason for designing the monthly output reports that were going back to the facilities.

The input system design was concerned with (1) making the best use of the organizational hierarchy (human factors) for the submission process; (2) designing input forms that were clear and requested the proper data; and (3) processing the data forms once they were received by the MEO ECMS staff.

In an effort to debug the input form and instructions (see appendix), a test was performed using the forms and instructions for collecting the historical data for the community colleges. The test proved to be useful, as it resulted in the necessary fine tuning to insure that the forms and instructions were well written for the full-scale input system implementation.

The system output, as mentioned earlier, was designed to motivate the facilities people to carry on with the system input. Preliminary inquiries to various department ECC's indicated that the system would be most likely to succeed if the facility people received an informational report in return for their submission of data and if this report contained some comparative basis for evaluating the status of their conservation efforts. The department ECC's also wanted summary reports on a quarterly basis to compare the relative performance of the facilities within their departments.

Task Force Organization

Based on the preliminary contacts with the various departments, as well as for the reasons outlined in Chapter 1, it was quite apparent that a task force was needed to coordinate the overall design and implementation of the ECMS. Initial contacts indicated that, while each department ECC was familiar with the operation of that particular department, he/she was not familiar with other departments or with the state as a whole. There was also a wide variation in the management and organizational techniques used within each department. By bringing the department ECC's together through a task force, interdepartmental communication channels could be opened and the departments could get the proper overall state perspective to the ECMS.

Also, by involving the department ECC's in the task force, their broad base of experience would be a valuable asset in trouble-shooting potential problem areas as well as identifying appropriate content for the output reports. This type of involvement gives ECC's a feeling of participation and hence a sense of responsibility for carrying through on their respective parts of the implementation of the system.

Initial Task Force Meeting

Preliminary conversations with the individual department energy conservation coordinators provide a sense of their feelings about the proposed ECMS. The aim of the group meeting, as outlined above, was to get their support for the project and to motivate them to implement the data input collection system. This was achieved through a type of persuasive approach to the meeting presentation. The presentation of the input system was based on the previous suggestions from the individuals concerning various aspects of the form or instructions, etc. Minor points relating to MEO requirements were left open to discussion for the task force to decide. The implementation procedure was explained, emphasizing that the responsibility rests with the department ECC's to insure that "their people" performed properly. Specifics of the operation of the input system were largely left to the individual ECC's.

Discussion of alternate types of output reports to be sent to the facilities was left open for discussion and suggestions. The only concern of MEO was that it should meet the facilities' requirements and provide them with the best possible information. The task force's ideals were built into the output reports. At this point, it was fairly clear that the task force was supportive of the effort and that they felt MEO was sincere in its intention of providing them with an energy management tool. The time scheduling was then reviewed, and another meeting of the task force was tentatively scheduled for 6 months later to assess any further needs or problems.

Review Meeting

In April 1978 , approximately 6 months after the initial meeting of the task force, a meeting was held to review the new state lighting code in addition to reviewing the ECMS. During discussion of the ECMS, several department representatives said that they thought the organized reporting of consumption data was beneficial. It not only provided them with the information, but it gave them a tool to raise the level of energy consciousness at the Executive level.

Since the first summary report for the first half of FY78 compared to FY76 had been released a few weeks earlier, this meeting also gave the MEO director an opportunity to address the task force regarding the relative energy consumption levels of various facilities, giving praise to those who had done well and encouraging the others to do better.

Implementation

In order to capitalize on the motivation generated by the initial task force meeting, input collection began as soon after the meeting as possible. The task force comments were incorporated into the input form and instruction package, and a letter of introduction was prepared for the facility ECC's. An instruction sheet for each department ECC was also prepared, outlining the steps to be taken as a minimum for implementation of the input system. A package for each department was then put together which contained an original input form with each facility's name and I.D. number, sets of instructions, and letters of introduction. In an effort to personalize the system, these packages were then hand-delivered to each department ECC four working days after the task force meeting.

Within State Departments

Once these packages were received by the departments, they had some flexibility in structuring the input system from their level down to the facilities. As mentioned earlier, the departments generally have different structures and modes of operation. By having the department ECC implement the input system within that department, the current operation of the department is not disrupted. Several of the departments added or modified certain suggested procedures to enhance the operation of the input system within their own "system."

Also, since the department ECC is responsible for implementing his particular piece of the overall system, he will become involved in the operation of the ECMS, thus adding his key input to the overall ECMS.

Within the Energy Office

The implementation of the input collection system also necessitated measures to be taken within the MEO to prepare for the onslaught of data forms. The two areas of concern were the processing of the incoming forms and the handling of questions concerning the forms or input procedures.

The processing of the incoming forms involves four basic steps. First, when the forms are received, a series of validation checks are manually performed on the data. This procedure is outlined in the Appendix. If there are any problems, the person whose name is on the form is contacted to clarify the data. Second, when the data are validated, the form is logged in on a completeness sheet and placed in an envelope ready for keypunching. Third, the forms are keypunched to a specified format approximately once a month. Fourth, the punched cards are then read into a transition file in the computer and are processed into the master file after the data have been checked once again.

Care was taken during the initial start-up phase to establish good working relationships with the facility ECC's. MEO made a concerted effort to respond immediately to all questions on filling out the forms and interpreting the instructions. More delicate situations arose when forms were submitted incorrectly, and someone had to contact the facility ECC to get the proper information and get him started on filling out the form properly. This was the more difficult situation to handle, since the facility ECC was being corrected for a mistake. Over a period of the first few months, however, the majority of the mistakes were corrected and good habits were developed.

Current Status

The system has been operational since mid-1977. Since that time, the software has been improved for more comprehensive monthly reports and yearly summary reports, as illustrated in the chapter on output. The software and user procedures are described in more detail in the accompanying manuals Software and Users' Manual for Energy Consumption Monitoring by Gary Bare and Daniel Kahn. Work is currently in progress on software changes to automate the summary reports.

In October 1978 NERCOM let a contract to develop a more extensive Consumption Monitoring System. This will be compatible with the present system, but will be written in the programming language COBOL instead of APL, allowing more universal usage and cheaper input/output. This software should be operational by March 1979.

APPENDIX A

List of Acronyms

Sample Massachusetts ECMS
Data Input Form and Instructions

Data Validation Checks

Sample List of Facilities

LIST OF ACRONYMS

APL	A Programming Language
A & F	Executive Office of Administration and Finance
CPU	Central Processing Unit
CRT	Cathode Ray Tube
DASD	Direct Access Storage Device
DBMS	Data Base Management System
ECC	Energy Conservation Coordinator
ECMS	Energy Consumption Monitoring System
ECPA	Energy Conservation and Production Act
EMS	Energy Management System
EPCA	Energy Policy and Conservation Act
FEA	Federal Energy Agency
MEO	Massachusetts Energy Office
NEEMIS	New England Energy Management Information Service
NERCOM	New England Regional Commission

ENERGY CONSUMPTION REPORTING FORM

50641	TYPICAL STATE FACILITY	20 OCTOBER
FACILITY ID #	FACILITY NAME	DATE PREPARED
	G. A. BARE	727-1990
	CONTACT PERSON	PHONE

REPORTING PERIOD: SEPT. (MONTH) 77 (YEAR) 01 (Leave Blank)

INSTRUCTIONS:

- Please read the instructions sheet before completing this form.
- Place a line through the quantity column if your facility does not use the indicated fuel type.
- Place zero in the quantity and cost columns if your facility did not consume any of the indicated fuel type during the reporting period.
- Place all numbers in the right most blocks.

Total number of degree days for this reporting period: 404

FUEL TYPE:		QUANTITY:		COST: $	¢
PURCHASED ELEC.	E	139240	KWH	7342	26
NATURAL GAS	N	16606	CCF	4875	54
PROPANE	P		GAL		
COAL	C		TONS		
OIL #2	2	0	GAL	0	00
OIL #4	4		GAL		
OIL #6	6	6177	EQV GAL	1868	40
PURCHASED STEAM	S		KILO LBS		

Do you have the capability to generate electricity? YES

If so, how many KWH were generated during this reporting period? 24,560

PLEASE MAIL TO:

COMMENTS:

Electricity billing period 9/03 - 10/04

NATURAL gas billing period 9/9 - 10/8

INSTRUCTIONS FOR ENERGY CONSUMPTION REPORTING FORM

1. Make copies of the form to insure that you have an adequate supply.

2. Complete one (1) form for each month. The completed form is due on the 21st day of the month following the month being reported (data for June is due the 21st of July).

3. The completed form should be mailed to the address at the bottom of the form.

4. Please use your FACILITY ID# on all forms.

5. REPORTING PERIOD: Whenever possible, use the first day of the month through the last day of the month. For some fuel types such as electricity and natural gas the billing period may run on a different monthly cycle. For these fuel types, use the billing period and note under the "Comments" section what reporting period you are using. Use the 15th of the month as the dividing date. Two examples follow:

   a) Billing period: May 9th thru June 8, 1977
      Reporting period: May 1977

   b) Billing period: May 21st thru June 21, 1977
      Reporting period: June 1977

6. DEGREE DAYS: Report the number of degree days for your facility as measured at the facility.

7. For steam and electricity, note that it is "Purchased" not generated.

8. For oil and coal, report the quantity <u>consumed</u>. Calculate the total cost based on your current cost per gallon. For #6 oil use equivalent gallons to calculate the cost.

9. Please make note of the units for different fuel types specified on the form. Make any necessary conversions to conform to the units specified. An explanation of the units follow:

   KWH - Kilowatt - hours

   CCF - hundred cubic feet. Another common unit is MCF which is thousand cubic feet. (MCF X 10 = CCF)

   Gal - Gallons

   Tons - 2000 pounds

   EQV GAL - Equivalent gallons, this is actual gallons corrected to 60 deg F to allow for density changes.

   KILO LBS - Thousand pounds

10. If you have the capability to generate electricity, please complete the two questions and include the amount of self-generated electricity.

11. A sample form has been completed and is attached. If you still have questions, please call the person whose name is on the bottom of the reporting form.

PROCEDURE FOR HANDLING INCOMING

ENERGY CONSUMPTION REPORTING FORMS

As You Receive The Forms

1. Stamp each form with the date received.

2. Enter the appropriate numbers in the boxes beside the date to indicate the reporting period. The order is: beginning year, month, and day then ending year, month, and day. For example, if the reporting period is the month of April, 1978, enter 780401 780430.

3. Keep all the forms together under proceeding to the next step.

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At Least Once A Week

4. Perform the attached list of data validation checks on each form and separate the bad or incomplete forms from the ones that pass all checks.

5. Log in the good forms by checking them off on the master completeness list and put the forms in a manila envelope marked "For Keypunching." Only put forms in this envelope that have been checked off on the completeness list and only check off the forms on the completeness list that go into this envelope.

6. Now you need to correct the data on the bad and incomplete forms. Once you become familiar with the data, you will be able to correct many of the mistakes by comparision with the listings of previously received data. In order to correct all other mistakes you should call the person whose name and phone number is on the form. They are usually very cooperative in getting the correct information back to you either right then or by calling you back. When the data meets all the validation checks you can go back to step 5.

7. If you receive any forms that are corrections for a previously submitted form, do not include them with the rest. The corrections will be made directly into the computer files

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On The 21st Of The Month

8. Theoretically, this is the date that you should have all of the forms for the previous month's energy consumption. Currently, the extended due date is the 10th of the following month.

9. Two working days before the due date, the departments that have facilities which have not sent in a form should be notified. Some departments

hold the forms until they have received forms from all the facilities in that department. Request that all the forms be mailed or delivered to MEO by the due date.

10. All forms should be validated and prepared for keypunching as soon after the due date as possible.

DATA VALIDATION CHECKS

Starting At The Top Of The Form

1. The facility I.D. number must match the number on the attached list for that facility name. Some facilities such as Danvers State Hospital try to use another State Identification Number. Make sure that all five (5) numbers are correct and easily readable.

2. The correct reporting period should be filled in as indicated in the preceeding procedures.

3. Heating degree days should be right justified whole numbers (no decimal). If there is no number in the boxes, put a "1" in the right most box.

4. The facility should have reported information for all fuel types that are checked on the attached list. Frequently encountered errors will include no information for fuel types such as natural gas or oil #2 when a zero should have been entered. This occurs primarily during the summer months. Also, a few facilities switch from natural gas to oil for heating depending on the availability of low-cost natural gas. This usually results in a "no information" type problem for the unused fuel type. By examining the data listings and after experience, zero's can be entered in many cases without calling the facility contact person to verify it. Until then, this problem results in an incomplete form.

5. All quantities should be right justified and be reported in whole numbers (no decimals). Decimals are sometimes included in the fuel types that are reported in gallons.

6. The quantities are to be checked to verify that they are in the proper units and are of a reasonable magnitude. An easy way to do this is to take the ratio of quantity to cost (in dollars) for each fuel type. This is a crude yet effective check that can be performed without any computations.

   Electricity - usually ok since numbers are typically taken from bills. Ratio is approximately 20 or 30 to 1.

   Natural Gas - Lots of errors. Usually off by a factor of 10 or 100 (reported in CF or MCF rather than CCF). Ratio is approximately 5 or 6 to 1.

Propane - Sometimes off by a factor of 10 or a decimal is included. Ratio is approximately 2 to 1.

Coal - Very rarely used. Ratio is approximately 1 to 50.

Oils - Sometimes have a decimal included. A few facilities use #5 and change #4 to #5 on the form. Make sure a "5" is in the box for fuel type. Ratio is approximately 2 or 3 to 1.

Steam - Sometimes reported in pounds instead of 1000 pounds. A few facilities report steam generated within their power plant. This should be crossed out. Ratio is approximately 1 to 7 or 8.

The ratios given are intended to be rough approximations and are good for 1978/79. When validating historical data, the ratios could be significantly different depending on the unit prices in effect at that time.

	10101	10102	10103	10104	10105	40101	40102	40103	40105	40106	40108	40109	40110
ELECTRICITY	X	X	X	X	X	X	X	X	X	X	X	X	X
NATURAL GAS			X				X		X		X	X	X
PROPANE						X	X			X	X		
COAL													
OIL #2						X	X	X	X	X	X		X
OIL #4													
OIL #5													
OIL #6						X	X		X	X	X	X	X
STEAM	X	X	X	X	X								

	40112	40113	40114	40115	40116	40117	40118	40119	40121	40122	40123	40107	40201
ELECTRICITY	X	X	X	X	X	X	X	X	X	X	X	X	X
NATURAL GAS	X	X			X	X	X	X	X		X	X	X
PROPANE		X	X	X	X					X			X
COAL					X								
OIL #2	X	X	X		X		X		X	X	X		
OIL #4													
OIL #5													
OIL #6	X	X	X	X	X		X	X		X	X		X
STEAM						X							

	40202	40203	40204	40205	40206	40207	40208	40401	40402	40403	40404	40405
ELECTRICITY	X	X	X	X	X	X	X	X	X	X	X	X
NATURAL GAS			X	X	X	X	X		X	X		X
PROPANE	X			X				X	X		X	
COAL												
OIL #2	X				X		X	X	X	X	X	
OIL #4									X			
OIL #5												
OIL #6	X	X	X	X	X	X		X	X	X	X	X
STEAM												

	40406	40409	40410	40411	41101	41201	50202	50203	50204	50205	50206	50207	50208
ELECTICITY	X	X	X	X	X	X	X	X	X	X	X	X	X
NATURAL GAS					X		X	X		X	X	X	X
PROPANE	X	X		X									X
COAL													
OIL #2	X		X	X			X	X	X	X		X	X
OIL #4							X				X		X
OIL #5	X												
OIL #6					X	X	X	X	X	X		X	
STEAM													

	50209	50210	50211	50301	50302	50401	50504	50505	50502	50603	50606	50602	50603
ELECTICITY	X	X	X	X	X	X	X	X	X	X	X	X	X
NATURAL GAS	X	X		X	X	X	X		X	X	X	X	
PROPANE		X	X				X		X				
COAL							X	X					
OIL #2	X			X	X	X	X		X				
OIL #4			X									X	
OIL #5	X												
OIL #6				X	X	X	X	X	X				
STEAM		X											

	50616	50604	50605	50606	50607	50608	50609	50611	50610	50612	50614	50613
ELECTICITY	X	X	X	X	X	X	X	X	X	X	X	X
NATURAL GAS	X				X	X	X	X	X	X	X	X
PROPANE												X
COAL												
OIL #2												X
OIL #4					X					X	X	X
OIL #5								X				
OIL #6												X
STEAM												

FUEL TYPES USED IN STATE FACILITIES

ID #	FACILITY NAME
10101	STATE HOUSE
10102	MC CORMACK BUILDING
10103	SALTONSTALL BUILDING
10104	HURLEY BUILDING
10105	LINDEMANN CENTER
40101	BELCHERTOWN STATE SCHOOL
40102	NORTHAMPTON STATE HOSPITAL
40103	GLAVIN REGIONAL CENTER
40104	GARDNER STATE HOSPITAL
40105	WORCESTER STATE HOSPITAL
40106	MONSON STATE HOSPITAL
40107	SOLOMON MENTAL HEALTH CENTER (LOWELL)
40108	FERNALD STATE SCHOOL
40109	METROPOLITAN STATE HOSPITAL
40110	J.T. BERRY REHABILITATION CENTER
40111	HOGAN REGIONAL CENTER
40112	DANVERS STATE HOSPITAL
40113	WRENTHAM STATE SCHOOL
40114	MEDFIELD STATE HOSPITAL
40115	WESTBORO STATE HOSPITAL
40116	CUSHING HOSPITAL
40117	SOLOMON CARTER FULLER MENTAL HEALTH CTR.
40118	MASS. MENTAL HEALTH CENTER
40119	BOSTON STATE HOSPITAL
40121	CORRIGAN MENTAL HEALTH CENTER
40122	DEVER STATE SCHOOL
40123	TAUNTON STATE HOSPITAL
40201	LAKEVILLE HOSPITAL
40202	PONDVILLE HOSPITAL
40203	RUTLAND HEIGHTS HOSPITAL
40204	WESTERN MASSACHUSETTS HOSPITAL
40205	MASSACHUSETTS HOSPITAL SCHOOL
40206	TEWKSBURY HOSPITAL
40207	SHATTUCK HOSPITAL
40208	INSTITUTE OF LABORATORIES
40401	M.C.I. BRIDGEWATER
40402	M.C.I. CONCORD
40403	M.C.I. FRAMINGHAM
40404	M.C.I. NORFOLK
40405	M.C.I. WALPOLE
40406	M.C.I. SHIRLEY
40409	M.C.I. MONROE
40410	M.C.I. WARWICK
40411	M.C.I. PLYMOUTH
41101	SOLDIERS HOME / CHELSA
41201	SOLDIERS HOME / HOLYOKE

ID #	FACILITY NAME
50202	BOSTON STATE COLLEGE
50203	BRIDGEWATER STATE COLLEGE
50204	FITCHBURG STATE COLLEGE
50205	FRAMINGHAM STATE COLLEGE
50206	NORTH ADAMS STATE COLLEGE
50207	SALEM STATE COLLEGE
50208	WESTFIELD STATE COLLEGE
50209	WORCESTER STATE COLLEGE
50210	MASS.COLLEGE OF ART
50211	MASS.MARITIME ACADEMY
50301	UNIVERSITY OF LOWELL - NORTH CAMPUS
50302	UNIVERSITY OF LOWELL - SOUTH CAMPUS
50401	SOUTHEASTERN MASSACHUSETTS UNIVERSITY
50502	UNIV OF MASS./ BOSTON (HARBOR)
50503	UNIV. OF MASS./ BOSTON (ARLINGTON ST.)
50504	UNIV. OF MASS./AMHERST (ACADEMIC)
50505	UNIV OF MASS./AMHERST (STUDENT RESD)
50506	UNIV. OF MASS./ WORCESTER
50602	BERKSHIRE COMMUNITY COLLEGE
50603	BRISTOL COMMUNITY COLLEGE
50604	CAPE COD COMMUNITY COLLEGE
50605	GREENFIELD COMMUNITY COLLEGE
50606	HOLYOKE COMMUNITY COLLEGE
50607	MASS. BAY COMMUNITY COLLEGE
50608	MASSASOIT COMMUNITY COLLEGE
50609	MT. WACHUSETT COMMUNITY COLLEGE
50610	NORTHERN ESSEX COMMUNITY COLLEGE
50611	NORTH SHORE COMMUNITY COLLEGE
50612	QUINSIGAMOND COMMUNITY COLLEGE
50613	SPRINGFIELD TECH. COMMUNITY COLLEGE
50614	ROXBURY COMMUNITY COLLEGE
50615	MIDDLESEX COMMUNITY COLLEGE
50616	BUNKER HILL COMMUNITY COLLEGE