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**A MICROCOMPUTER BASED
ENERGY MONITORING AND REPORTING SYSTEM
FOR VIRGINIA STATE FACILITIES**

by

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(ABSTRACT)

Effective energy management programs rely upon readily accessible energy consumption information. This thesis presents a Lotus Symphony based microcomputer system developed to monitor, analyze, and report on energy usage for a select group of Virginia state facilities. A review of significant program routines and procedures is presented, along with key assumptions and limitations of the system, and example inputs and outputs. A User's Guide is also included to aid first time users of Symphony and/or the Energy Monitoring and Reporting System (EMRS).

Available system outputs, in the form of spreadsheet printouts and graphs, enable detailing energy consumption patterns for each facility by fuel type for any given year. The capability of outlining the progression of

a facility's energy management program is provided by comparison of a given year's energy consumption records to the previous and base (FY 1985-86) years. In addition, facilities with similar operational characteristics were segregated into divisions, providing the capability to rank facilities within divisions based upon several energy consumption criteria.

Extensive use of the Symphony Command (or Macro) Language permitted creation of customized, interactive menus, which allows those not familiar with Lotus Symphony to fully utilize the capabilities of the EMRS.

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CHAPTER I
INTRODUCTION

1.1 Background

During the period from Fiscal 1980 to 1984, energy expenditures for Virginia state-owned facilities rose 47 percent from \$56.4 million to 83.1 million [1]. This dramatic rise in expenditures for energy (electricity, oil, natural gas, and coal) prompted legislative action by the General Assembly in February of 1983 in the form of House Joint Resolution (HJR) 28. HJR 28 confronted the issue of rising energy costs in state facilities and the liability that these costs were placing on facility and agency operating budgets. The Department of General Services (DGS) was requested, within the scope of HJR 28, to examine opportunities for controlling these escalating costs.

The Department of General Services' response to the above request outlined an eleven point proposal for reducing energy costs in state facilities. The main focal point of this proposal was the establishment of a State Energy Conservation Team which would have overall responsibility for establishing and directing a state-wide energy conservation program.

As part of its energy program duties, the State Energy Conservation Team was directed to implement a statewide energy usage tracking and reporting system. Justification for this tracking and reporting system was established based on the reasoning that the effectiveness of the conservation program could not be evaluated without a means of determining energy consumption levels and patterns. Other programs in use; the Cost Accounting and Reporting System (CARS) and the Fixed Assets Accounting and Control System (FAACS), did not provide for the needed depth of analysis nor the accuracy required. More precisely, the energy tracking and reporting system would also enable the State of Virginia to:

- a. Identify facilities with wasteful operating practices;
- b. Determine which facilities are operating with a high level of energy effectiveness for the purpose of identifying cost effective operating procedures and for the purpose of a proposed awards program;
- c. Provide a means for recording unit consumption by fuel (gal, mcf, etc.), fuel unit costs (\$/gal, \$/mcf, etc.), and expenditure trends to aid in accurate planning and budgeting based upon proven trends;
- d. Identify which conservation practices and actions are the most effective;
- e. Identify prime conservation opportunities, thereby making allocation of limited capital outlay funds more cost effective;

- f. Promote a higher level of energy conservation awareness in facility operating personnel through activities associated with the tracking and reporting system [1,4];
- g. Provide a base for energy strategic planning.

1.2 Scope of Research

By necessity effective energy management programs, whether in government or private industry, are dependent upon the successful coordination of several key aspects. A brief description of these follows:

- a. Management Commitment
All successful programs, including energy management, must have the commitment of the highest-level decision makers. If such commitment is not forthcoming, middle and lower-level managers will naturally focus their attention and resources elsewhere, and progress towards managing energy consumption and costs will suffer;
- b. Energy Surveys and Audits
These must be carried out to identify opportunities for reducing energy usage. Areas of intensive energy use should be surveyed first and most thoroughly;
- c. Energy Retrofits and Conservation Projects
Based upon the results of energy surveys, allocation of limited funds should be made to those projects having the most favorable impact on reducing energy consumption;
- d. Personnel Participation and Motivation
Once high-level commitment has been established, the persons with the greatest influence on the success of an energy program are the end-users of energy; the process or building operators and occupants. Relevant methods of motivating these persons to

participate in the program are essential. Awards for successful energy reduction ideas are a prime example of employee motivation. Participation includes adequate education and training of personnel in energy conservation techniques and in keeping personnel informed on levels of energy usage and goals relating to reducing energy consumption. Personnel should be shown why, and more importantly how, they can participate to save energy;

e. Maintenance

Effective maintenance and conservation go hand in hand. It is impossible to effectively manage energy usage while allowing maintenance of prime energy using equipment to become neglected;

f. Monitoring and Analyzing Energy Usage

For an energy conservation program to be truly complete, it is imperative to determine where energy is being consumed. Cost and consumption patterns must be analyzed to determine the relative effectiveness of each facilities' energy program. This is the best method of insuring the proper allocation of available resources, whether financial or technical.

This thesis focuses upon developing an energy monitoring and reporting system for the one-hundred largest facilities owned and operated by the Commonwealth of Virginia. It is intended primarily for use by the State Energy Conservation Team. It is clear from the above discussion that this monitoring and analysis system is but one of several tools necessary to accomplish the mission of managing energy consumption within state facilities.

While intended primarily for use by the State of Virginia, the monitoring and reporting system developed herein is applicable to a wide variety of areas within government and private industry. Likewise, it is reasonable to assume that this research could be modified to provide for the needs of many possible secondary users, including county and local governing bodies, building managers, and private industry energy users. These secondary users, however, are limited to the objectives of this research, which are discussed next.

1.3 Statement of Objectives

Reasons for conducting the research are twofold. First, no acceptable methods of monitoring and analyzing individual facility energy usage (both expenditures and fuel unit consumption) existed when the State Energy Conservation Team came into existence. Second, as previously discussed, an energy monitoring and reporting system is one of the key ingredients for a successful energy conservation program.

With these ideas in mind, the main objective of this research is to develop a Lotus Symphony based algorithm to provide critical energy consumption

information for use by the State Energy Conservation Team in development of a statewide energy conservation program. This information, which would be input, processed, evaluated and disseminated by the Energy Team to the various branch secretaries, department, and facility heads within state government, would include monthly and annual descriptions of department and facility fuel: unit consumption, BTU consumption, expenditures, expenditure and BTU consumption per gross square foot of conditioned space with BTU consumption adjusted for variations in weather, unit costs, and costs per million BTUs for each fuel. The above information was desired to be made available in both tabular (printout) and graphical form.

In addition, it was necessary to provide a means for ranking each facility within a department based upon any one of the above criteria on an annual basis.

Finally, a method of comparing each of the above quantities for the present versus the previous year and the present versus a base year was desired to determine the progression of a given facility's energy program. This comparison information was also desired in tabular and graphical forms.

There are over seven-hundred state-owned facilities, but the research objective was limited to the

top one-hundred in energy expenditure for 1986. This limit was established in order to have a manageable base of information, as data would be collected and input manually into the program data files with limited personnel resources. This limit, however, would permit monitoring and reporting energy usage for facilities that comprised eighty-five percent of the total state energy expenditures for Fiscal 1986 [9]. It should be noted though, that efforts were made to allow for readily expanding the number of facilities being monitored without additional programming requirements.

In accomplishing the primary objective of monitoring and analyzing energy usage in the one-hundred largest facilities, it was necessary to create a program that would be easy to use, requiring no programming experience on the part of the user. In addition, a minimum of experience in working with computers and peripheral devices (printers, plotters, and tape backup systems) would be required to operate the program.

Finally, it is important to keep in mind that it was not an objective of this research to develop a building energy load estimating program, similar to the Carrier E-20, Trane Trace, ASEAM, and various other

programs, but rather to develop an energy usage monitoring and reporting system.

1.4 Organization of Research

The presentation of the research proceeds in the following manner. Chapter I provides an introduction to the strategy behind an energy monitoring and reporting system and demonstrates how such a system is involved in a total energy management program. Chapter I also covers the scope of the research and the statement of objectives.

Chapter II reviews the relevant literature. Literature relating to energy monitoring and reporting systems in general is discussed. In addition, literature pertaining to past methods used by the State of Virginia to monitor energy costs will be reviewed.

In Chapter III, the program development methodology is presented. The general program purpose, desired form and outputs are explained, along with assumptions made during development. A brief explanation of each program module is included. In addition, methods for receiving energy and related data from facilities and other sources is discussed.

Chapter IV presents various examples of the program developed. The program capabilities and limitations are

clearly defined using a presentation of example inputs and outputs, including data and program files. An analysis and evaluation of the program is also presented, followed by a description of hardware and software requirements to permit proper program operation.

Chapter V presents conclusions and recommendations concerning the research. The conclusions section focuses on whether the goals of the research were accomplished. The recommendations section focuses upon how the program and the program outputs should be utilized. In addition, areas of further research are presented.

Appendix A presents a list of the one-hundred facilities chosen for inclusion into the EMRS.

Finally, Appendix B presents a User's Guide to assist in the operation of the program and to better familiarize the reader with the program developed.

CHAPTER II
LITERATURE REVIEW

2.1 Energy Monitoring and Reporting Systems-
A General Discussion

The discussion of literature on this topic begins with a definition of an Energy Monitoring and Reporting System (EMRS). Magorian [1] defines an EMRS as an accounting system designed specifically to provide the correct information to understand and control energy costs. Weisner and Codina [2] further clarify this definition by stating that an EMRS is a formal method of recording and analyzing energy uses and costs for use in developing reports on: energy expenditures, energy use patterns, effects of conservation efforts, recommendations on conservation actions, and preparation of energy budgets. These definitions enable the reader to grasp the basic principle behind an EMRS which becomes even clearer as the critical need for an EMRS within the scope of a total energy management program is understood.

Magorian [1], who provides the most detailed and in-depth discussion on developing an EMRS, summarizes the use of an EMRS as an effective tool to identify wasteful practices, target areas for improvement, budget more accurately, catch out-of-range utility bills, and promote energy cost savings. Stebbings [3] further illustrates

the necessity of an EMRS within an energy program by logically assessing that an energy program will successfully progress as energy facts and the role of each individual within the program are defined and explained, and as energy goals are set. Furthermore, these elements are aided by a logical and straightforward EMRS. This discussion on the basis of an EMRS, echos the purposes of a state of Virginia EMRS as outlined by Justice [4] and in the background section (1.1) of this research.

There are three types or levels of Energy Monitoring and Reporting Systems:

- a. Individual Building Level
- b. Facility or Group of Buildings Level
- c. Multi-Facilities Level

A discussion of each of these levels is given next to familiarize the reader with the similarities and differences in these systems.

The first, and most basic level is the building EMRS. In a system of this type, energy flows as well as operational and building characteristics are evaluated on a building by building basis to determine the effectiveness of each structure's use of energy. A system of this type was developed by the State of Georgia [5,6] for their state energy conservation program. An EMRS on

this level presents extensive utility data on each building from which an analysis and comparison of energy flows can be made. However, a serious disadvantage to an EMRS of this type is that rarely are all buildings individually metered for electricity, natural gas or other energy sources. Similarly, a group of buildings often share a common heating or cooling source (for example, a central heating plant supplying steam to campus buildings at a university). Unless all buildings are individually metered for each energy source flow into the building, estimates (usually on a square footage basis) are then used to derive energy usage. This leads to similar energy consumption patterns for a wide variety of structures. In addition, the original concept of the EMRS, which is to provide accurate information on energy consumption patterns, becomes diluted. Therefore, unless each buildings's energy source flows are individually metered this type of EMRS will not become an effective tool to manage energy consumption.

The next logical type of EMRS, following the arguments given above, is the facility EMRS. This type of EMRS tends to overcome the possible metering shortcomings of an individual building by building system. Unfortunately, there are disadvantages to this level of

EMRS as well. The main problem being that each building cannot be scrutinized for precise energy usage. However, the energy usage patterns of the facility can be monitored and analyzed over a period of time with much greater accuracy because no assumptions or estimations need to be made.

The final type of EMRS to be discussed is a system based upon a group of facilities. An example of this type of system would be an EMRS used to compare energy usage patterns for different manufacturing plants for a corporation. This research is based upon this type of EMRS by monitoring and reporting on the energy consumption patterns of a wide variety of facilities within the Commonwealth of Virginia. This type of system is normally broken down into a number of sub-systems to allow comparing energy usage patterns for facilities with common purpose, population, building, and operational characteristics. Thus, for a large corporation, rubber product plants would be compared to rubber product plants, and fertilizer production facilities would be compared to fertilizer production facilities and so forth [1].

Magorian [1] further establishes a basis for developing an EMRS that can target energy consumption for the various areas of energy use, including: building,

heating and cooling energy, process or product manufacturing energy, and vehicle or transportation energy. However, the metering requirements for establishing these energy flows in a facility or multi-facility EMRS are even greater than those for a building by building EMRS discussed earlier. With no facilities within the State of Virginia possessing such detailed metering capabilities, this type of system was not pursued, but was discussed here for completeness.

Each EMRS discussed has two distinct parts. The first is the recording or monitoring of energy usage at each location whether at the building or facility level. This can be accomplished by input of utility bills and records of energy purchases. The second phase of an EMRS is the reporting or analyzing of energy use and energy usage patterns. This second phase establishes the need for a systematic approach to compare energy consumption levels at different locations that accounts for the variables that affect energy consumption. This is the basis for development of an energy index as described in the works of Miller [7] and Axel [8].

Miller [7] and Axel [8] define an energy index (EI) as a method for determining the amount of energy

required to perform a certain task. Establishing this definition in equation form yields:

$$\text{Energy Consumption} = \text{EI} \times \text{Variable(s)} \quad (2.1)$$

It is important to note the possible plurality of the variable contained in equation 2.1. A simple example of a singular variable EI would be to base the energy consumption of a vehicle, in gallons of gasoline, upon an EI of gallons of gasoline consumed per mile traveled. Thus, equation 2.1 becomes:

$$\text{Gallons Gasoline} = \frac{\text{Gallons}}{\text{Mile}} \times \text{Miles Traveled} \quad (2.2)$$

Here the energy index is multiplied by a single variable, miles traveled, to determine energy consumption in gallons of gasoline. Axel [8] states that corporations involved in energy conservation programs are quick to point out the possible shortcomings in use of a single variable energy index.

Such shortcomings arise from the fact that very few real world situations regarding energy consumption can be modeled effectively based upon a single variable as in equation 2.2. For example, building energy usage is affected by a wide variety of factors including, but not

limited to: building square footage and volume, exposed exterior area, construction characteristics, building occupancy, building age, location, severity of weather including temperature, wind and humidity variations, controlled interior conditions, and the characteristics of conditioning equipment in use. Thus, some rational basis should be used for developing a reasonable energy index without carrying the analysis to the extreme. Miller [7] provides a method for establishing a basis upon which to develop an energy index. This method involves determining or estimating the level of energy use, developing a list of major variables or factors affecting energy use and determining a relationship between these variables and the energy consumed. However, Axel [8] notes that once an energy index is developed, it may become necessary to adjust the index due to changes in the variable(s). Such changes could include fluctuations in a plant's product mix, changes in services provided, and even the effect of a building's deteriorating energy efficiency due to aging. Regardless of the index chosen, a sound and rational index is vital to allow for comparison of energy performance between similar locations.

In addition to the need for an energy index presented above, Miller [7] provides three further uses of an energy index. These uses are to: establish a measurable goal for each facility based upon the lowest energy index, provide a means to monitor the operating efficiency of a facility, and determine the effectiveness of various conservation measures undertaken. Thus, it is clearly visible that development and use of an energy index is vital to provide a means to accomplish the second part of an EMRS, which is to report and analyze energy use and energy usage patterns.

With the definition and need for an EMRS established, and the basis for an energy index defined, several additional basic features of an EMRS remain to be discussed. These features include: data source options, validation of data, types of desirable output, and insuring a reliable, maintainable, and expandable system.

Data source option, as presented by Magorian [1], generally are limited to two areas. The first source option is to obtain energy usage data directly from utilities and vendors, such as oil, electricity, and natural gas suppliers. The second option is to obtain input data from within the organization that will use the

EMRS being developed. Each of these options has certain advantages and disadvantages. The data source option chosen for this research, and the reasons behind this choice, is outlined in Chapter III which deals with the methodology used in developing the EMRS in use by the State of Virginia.

Once the data source option has been chosen, it is desirable to insure data validation. Validation is particularly critical in insuring the reliability of the EMRS developed. Again, data validation methods used for the research are discussed in the next chapter.

A major reason for the existence of an EMRS is the output of reports regarding energy use. Magorian [1], and Weisner and Codina [2] provide an outline of basic outputs that should be incorporated into each EMRS. These outputs include, but are not limited to:

- a. General building or facility information including name, location, and square footage;
- b. Monthly and annual summaries of energy consumption and expenditures by fuel type;
- c. Provisions for graphic display of items given in b;
- d. Output of comparisons on energy consumed for buildings or facilities based upon an energy index.

Efforts to include each of the above items were of prime importance in creating the program code which forms the basis of the EMRS developed.

The final feature of any effective and useful EMRS is the need for system reliability, maintainability, and expandability [1]. The first two features can be insured by development of an EMRS based upon established, reliable programming languages, use of structured programming, and providing a high standard of documentation. System expandability is insured through well documented programming techniques allowing for additional buildings or facilities to be included within the scope of the EMRS developed. Each of these final three features, as they relate to the research, are discussed in Chapter III.

2.2 Past Energy Monitoring Methods- State of Virginia

A description of the manner in which energy expenditures for state-owned facilities were monitored prior to the initiation of methods presented in this research is necessary for a better understanding of the need for this research. It should be noted at the outset of this section that past energy consumption monitoring systems used by the State of Virginia dealt only with

energy expenditures. Therefore, for any given facility the only information attainable was expenditures for electricity, fuel oil, natural and propane gas, and coal. No system existed that could be used to determine unit consumption by fuel type. In addition, problems exist in the manner in which expenditures are tabulated. For example, all types of fuel oil, from kerosene to number six fuel oil, are grouped together under the single heading of fuel oil. Similarly natural and propane gas costs are tabulated under the title of gas. Thus, no EMRS, as defined in section 2.1, existed for state-owned buildings prior to conducting this research.

The primary system utilized to monitor energy costs in previous years was part of a much larger system used by the Department of Accounts (DOA) to track all expenditures within state-operated facilities. This system is known as the Cost Accounting and Reporting System (CARS) and is an accounting system used to monitor costs for all state purchases, from office supplies and medical equipment to costs for janitorial services and vehicle repairs. Sub-program 482 of the CARS (Object Codes Relating to Energy Use) provides for tabulating energy expenditures for each state agency [9].

Recording expenditures by agency leads to yet another deficiency in the CARS for monitoring energy expenditures. The problem arises from the fact that certain agencies are made up of more than one facility. For instance, the agency of Northern Virginia Community College is made up of five distinct and separate campuses. Therefore, no method exists for establishing energy costs for each facility contained within multi-facility agencies. A sample printout from sub-program 482 is presented in Figure 1, [9].

However crude it may be, sub-program 482 provides some meaningful data that has permitted establishing major energy consuming agencies, expressing statewide costs by fuel type, and outlining general, broad-based conservation objectives. These types of information are presented in reference [10], which outlines a five-year summary of energy costs in state facilities from Fiscal 1981 to Fiscal 1985. Included in reference [10], and shown in Figures 2, 3, and 4, is a presentation of energy costs over the five-year period FY 1981-1985, and a breakdown of expenditures by fuel type and by branch of government for Fiscal 1985.

Program Act482

Commonwealth of Virginia
Department of Accounts
Object Codes Relating to Energy

Run Date 9/22/86
Run Time 15:01:36
Report Page 134

Fiscal Year 1985
Agency 000 - Example Agency

Object Code	Title	Expenditures
1231	Electricity	\$ 3,517,118
1331	Coal	1,700
1332	Fuel Oil	895,112
1333	Gas, Natural or Propane	10,173
	TOTALS	\$ 4,424,103

Figure 1. Example Printout from CARS Sub-Program 482

These three excerpts are presented to familiarize the reader with energy expenditure patterns and levels within Virginia state-owned facilities, and to present a clearer understanding of the need for an effective EMRS.

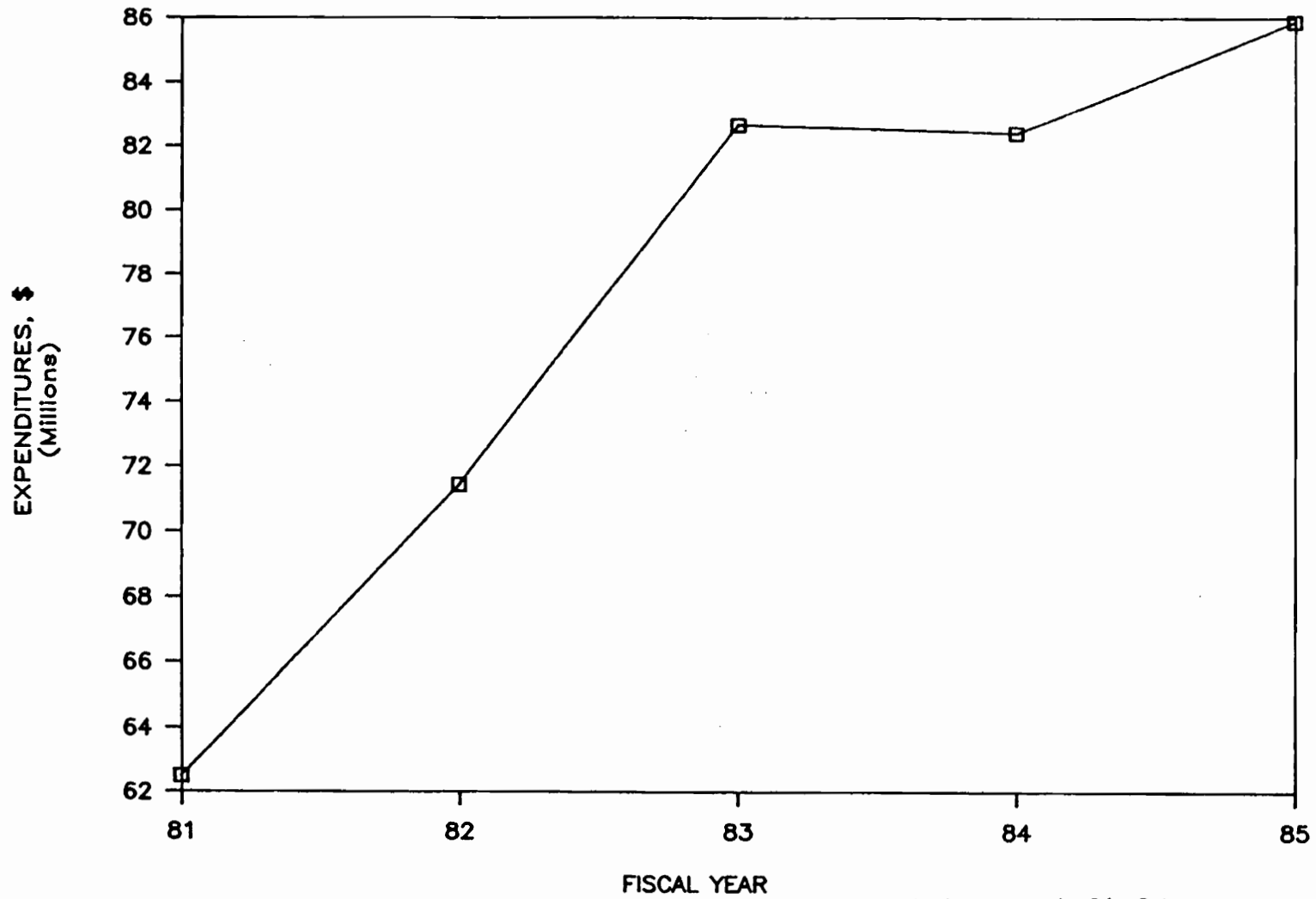


Figure 2. Energy Expenditures in State Facilities FY 1981-85

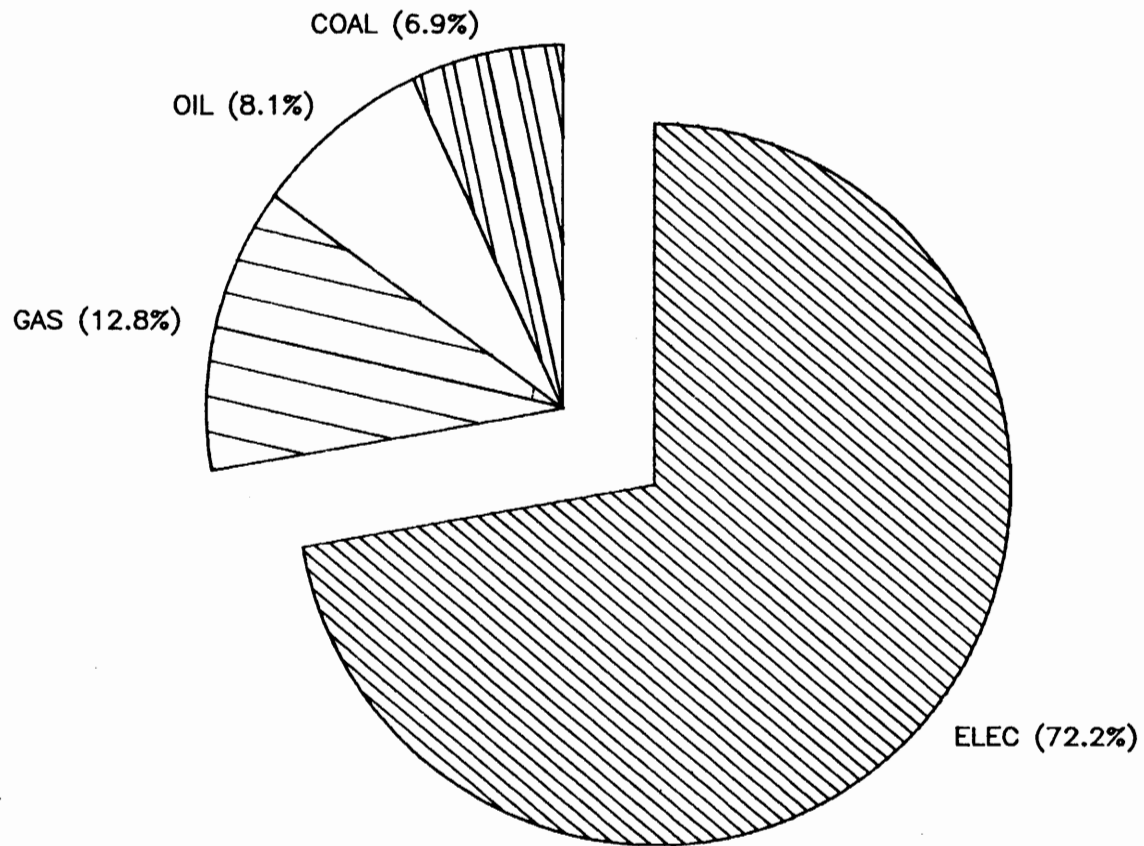


Figure 3. Energy Expenditures in State Facilities, FY 1985 By Fuel

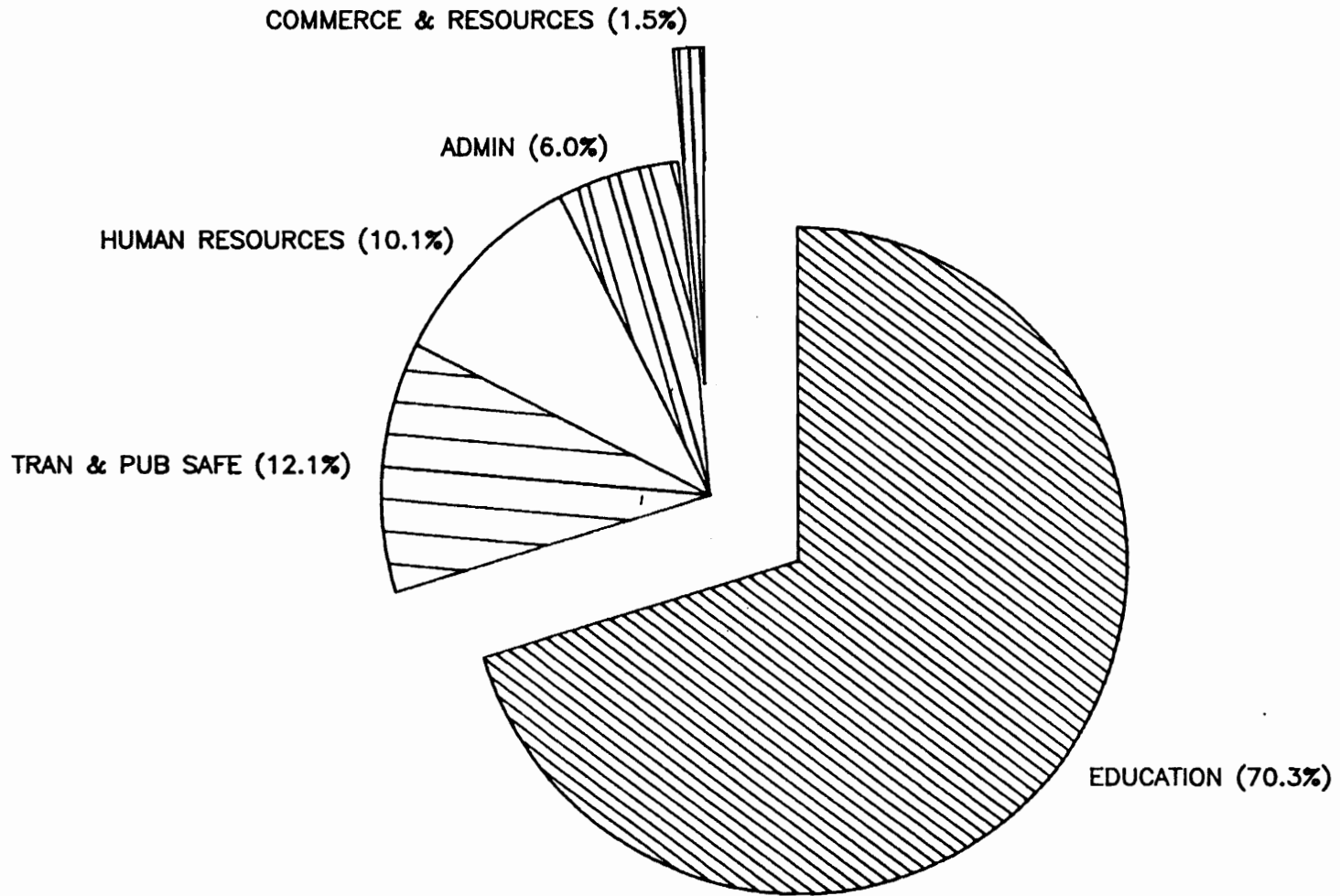


Figure 4. Energy Expenditures in State Facilities, FY 1985 By Branch

CHAPTER III

METHODOLOGY AND SYSTEM DEVELOPMENT

3.1 Available Resources

As outlined in Chapter II, the existing method of monitoring energy usage for state-operated facilities relies primarily on the use of the CARS sub-program 482. This sub-program, however, deals only with energy expenditures by fuel type, and for various reasons previously presented, is inadequate as a tool to monitor and report energy usage on a statewide basis. Thus, to effectively manage the energy resources of the Commonwealth of Virginia the decision was made to develop a true EMRS for state-operated facilities. It was also necessary to decide whether to attempt the development of the system in-house by the State Energy Conservation Team or through use of an outside consultant. Therefore, the first efforts towards establishment of an EMRS were to establish needs and resources.

Program development would need to be based upon available resources in the context that resources refers to available finances, technical expertise, and computer hardware. Financial resources available to the Team consisted solely of the Team's operating budget. No additional funds had been set aside for the purpose of

developing a statewide EMRS. This factor alone had the greatest influence in establishing the methodology used to conduct the research.

The second resource upon which to base the decision of the program development relates to available technical expertise to develop and operate the proposed EMRS. Existing personnel of the State Energy Conservation Team consists of three members, including the Manager and two Associates. With the extent of the Manager's duties excluding him from consideration, operation of the EMRS would be limited to the two Associate Energy Managers. Again, the workload of the two Associates would not allow either to give full-time attention to operation of the EMRS after its development. Therefore, by necessity the system would require ease of use. Thus, the first constraint on the system would be complete user-friendliness. Programming experience could not be a prerequisite to use of the EMRS. In addition, to alleviate any problems that might arise from personnel turnover, it is desirable to create a system that can be understood in a short time frame hopefully by use of the system itself and not by requiring extensive study of documentation and reference manuals.

The last resource available, was existing computer hardware and accessories. This consists of a single IBM PC-AT with 512 kilobytes (k) of Random Access Memory (RAM), two 40 Megabyte (MB) fixed drives and a single 1.2 Mb diskette drive. Accessories available include an IBM color-display monitor, an Okidata 2410 Pacemark printer, and a Maynard Maynstream 60 tape backup system.

These are the available resources upon which a decision would be made whether to proceed with system development in-house or with use of outside technical assistance. This decision would also need to take into account the desired program features.

3.2 Desired System Features

Based upon the needs of the Energy Team and the desirable outputs of monitoring and reporting systems as outlined in Chapter II, the following features were desired to be incorporated into the system developed. First, it was desirable to obtain printouts and graphs of energy usage information (units consumed, BTU consumption, expenditures, unit costs, energy costs per square foot of conditioned space and fuel costs per million BTUs) for any facility for any chosen year. Second, it was important to develop a system that would be capable of comparing the

above information for several years at a time in order to ascertain the progression of a facility's energy conservation program. Third, a means for detailing energy usage information for each department within state government would allow presentation of comprehensive reports to department heads who have direct supervision over many state facilities (e.g. the Department of Corrections). This report would include a listing of the aforementioned energy information for each facility as well as a total for all facilities combined. Finally, a method for ranking facilities within a department as to energy efficiency would allow for logically addressing the needs of those facilities most requiring energy conservation assistance.

3.3 Defining System Development Method

After developing a blueprint of the types of information that would be generated from the EMRS and outlining the available resources, it was necessary to determine whether the system would be developed in-house or through the use of outside assistance. This decision was arrived at by assessing two major factors. First, financial resources of the Energy Team were limited, thus restraining the choice of opting for outside assistance.

Second, if the program was developed in-house utilizing members of the Energy Team, who would be involved with each step, it was felt that the system developed would be superior and the possibility of future problems would be lessened. Therefore, it was decided to proceed with development using the resources of the Energy Team.

Once this decision was made, it remained to be decided whether to develop an EMRS "from scratch" or to utilize an available off-the-shelf system. A review of available programs to monitor and analyze energy consumption revealed the primary energy accounting program known as the FASER program. After a review of the FASER program, it was established that if an EMRS were to be developed which could provide for the necessary outputs desired while remaining relatively simple to use, it would be necessary to design the system utilizing an available common programming language. This decision was finalized after a further review of graphic output quality from the FASER program and realization that only a custom-programmed copy of the FASER software would be capable of handling the exacting needs of the Energy Team. Graphics quality was of primary importance since reports generated from the EMRS would be distributed across the state to

facilities as well as to agency and department heads and to the secretaries of each branch of state government. Furthermore, the costs of obtaining a custom-programmed copy of the FASER program would exceed available financial resources. Therefore, only one avenue remained open for development of a statewide EMRS, in-house, using a common programming language.

3.4 Defining Program Language and System Scale

Once the decision was made to develop the EMRS completely in-house, the search began for establishing which programming language would best allow for development of the system desired. Based on the combined experience of the members of the Energy Team, the programming language chosen was Lotus Symphony.

The next step in the development was the establishment of a limit of the number of facilities to be monitored. The need to limit the scale of the proposed EMRS arose from the need to match the experience that members of the Energy Team had in developing such systems, and the desire to develop a pilot system which could effectively monitor and analyze the majority of state facility energy usage. Development of a pilot program was deemed necessary to determine the pros and cons of system

design options while actually monitoring an effective portion of state facility energy usage. In addition, much needed experience could be gained that could be used in developing a broader-based system. Finally, it was desirable to limit the number of facilities being monitored because of limited personnel for operation of the system. Once a pilot program had been proven successful, additional manpower and budgetary resources could be justified to permit expanding the system.

The basis for determining the number of facilities to be included within this pilot EMRS was established using the levels of energy expenditures for Fiscal 1986. Since at that time only cost data was being monitored, and again on a broad agency basis, this was the only means upon which to determine which facilities would be monitored. It was desired to monitor a sufficient number of facilities to adequately comprise the majority of energy expenditures. From energy expenditure records presented in the CARS sub-program 482, it was determined that the one-hundred top facilities, comprised 85% of all expenditures. Furthermore, these one-hundred facilities were logically assigned within the organizational structure of state government to provide monitoring of energy usage for the

largest five departments in the state. This included: Universities and Four-Year Colleges, Community Colleges, and the Departments of Mental Health, Corrections, and General Services. It was a goal of this research to create a system that would enable comparing energy usage statistics between facilities with similar types of operation. Therefore, it was necessary to define which types of facilities would be grouped together. Thus, factors such as: facility services provided, hours of operation, presence of on-site living units, and needs for special indoor temperature requirements for occupants were assessed and provided the basis for grouping the one-hundred facilities into five major categories. These categories are similar to the organizational structure of Virginia state government which is presented in Figure 5. These five categories are:

1. Universities and Four-Year Colleges;
2. Virginia Community Colleges;
3. Department of Corrections;
4. Department of Mental Health and Mental Retardation, Virginia Schools for the Deaf and Blind, and the Department of Rehabilitative Services;

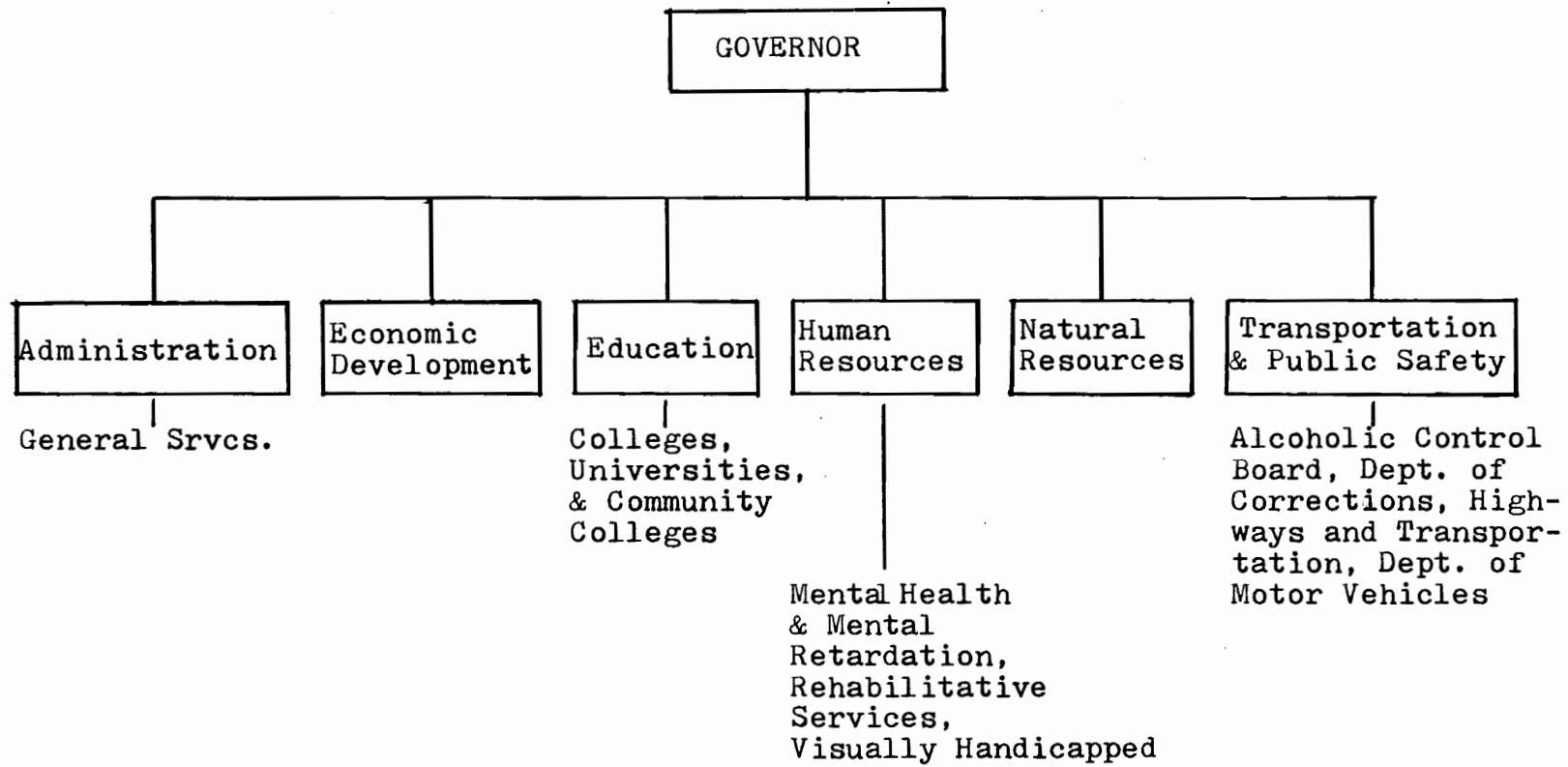


Figure 5. Organizational Structure of Virginia State Government, 1986

5. Department of General Services, The Science Museum of Virginia, The Virginia Museum of Fine Arts, and the Department of the Visually Handicapped.

A listing of each facility within the above categories is presented in Appendix A.

With system scale defined to these five categories and one-hundred facilities, and with development to proceed in-house using Lotus Symphony, it remained to define a means for comparing energy consumption levels between facilities in each category. In addition, data source options remained to be chosen and a means for data validation was necessary to insure system success.

3.5 Development of Methods to Compare Energy Usage Between Facilities

A key aspect of an EMRS is the ability to compare the energy efficiency of facilities being monitored. The ability to perform this task is directly related to development of an energy index (EI). This index requires defining variables that affect energy usage.

For the research at hand, this meant evaluating variables that affect energy use for a wide variety of facility types. As outlined in Chapter II, the possible list of variables affecting energy use can become

unmanageable unless an attempt is made to focus upon the primary factors which cause energy consumption levels to fluctuate. Thus, after an evaluation of the variables affecting energy usage in state facilities including: square footage of conditioned space; relative severity of winter and summer temperatures; levels of occupancy including patients, inmates, and staff; age of buildings at each facility, and types of conditioning equipment in service, it was determined that the first two factors have the greatest effect on energy usage. Thus, the energy index to be developed would rely upon building square footage and severity of winter and summer temperature conditions (heating and cooling degree days).

Choice of these two factors alone was based upon the following. First, these types of information are readily available. Square footage data are maintained for each state facility at each location as well as through a central system, similar to CARS, known as the Fixed Assets Accounting Control System (FAACS). Furthermore, obtaining square footage of building space using two separate means (facility reporting and FAACS) would enable validating square footage figures utilized. Heating and cooling degree days for each facility can be readily determined by

dividing the state into its weather regions in the manner shown in Figure 6. Each weather region is identified by a climatological weather station by the National Weather Service (NWS). Thus, weather data is readily available through monthly and annual reports received from the NWS; so accuracy in weather data is insured.

In an attempt to develop a system which would be reliable, maintainable, and easily usable, the factors of occupancy, building age, and conditioning equipment in use were not included. Occupancy levels at state institutions basically affect energy consumption through increased energy requirements for meals and laundry needs. However, the majority of energy consumption in state facilities, as formulated by the author through energy surveys of each type of facility, is through requirements for heating, cooling, and lighting. In addition, efforts to obtain accurate occupancy levels from each facility would present additional problems because such levels fluctuate from week to week and would be difficult to incorporate effectively into an EMRS. Similarly, efforts to determine energy usage for groups of buildings within defined age brackets or by types of conditioning equipment in use would create a

<u>Region</u>	<u>Weather Data From:</u>
1	Bristol
2	Roanoke
3	Lynchburg
4	Wash.-Dulles AP
5	Richmond
6	Norfolk

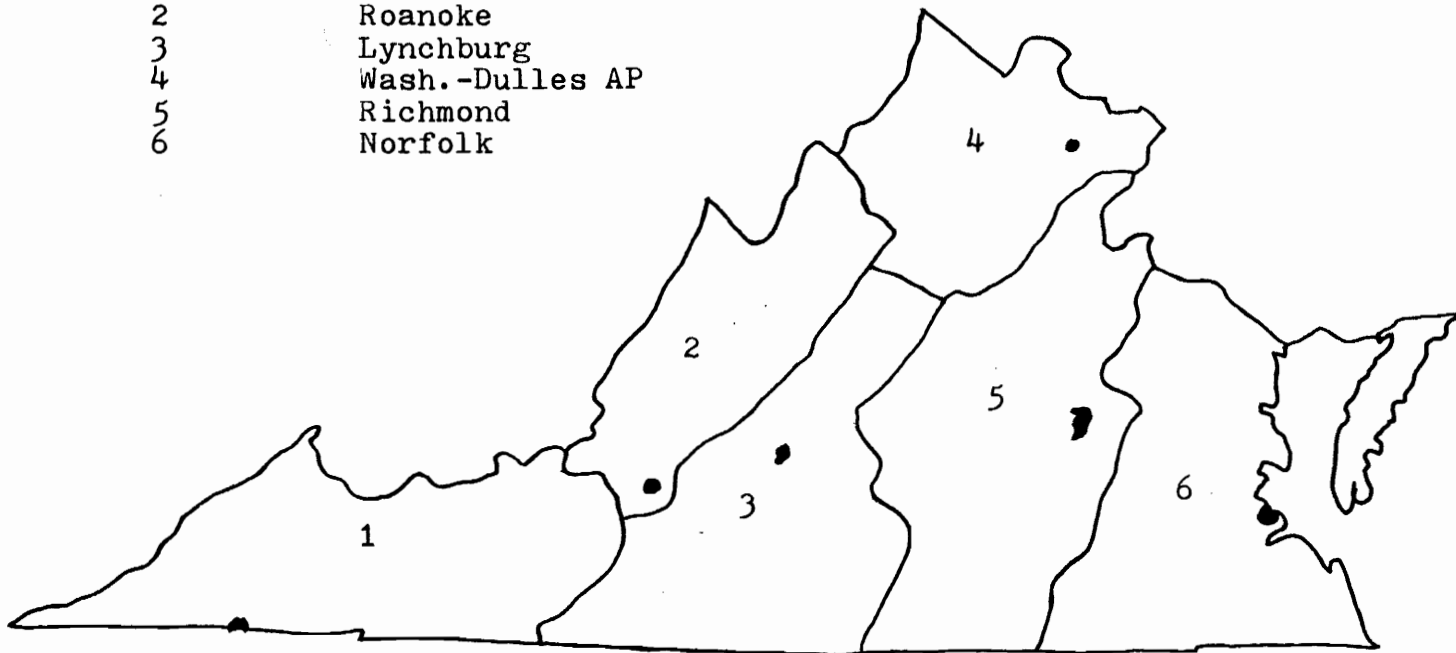


Figure 6. Weather Regions in Virginia

system with extensive complexity. A system of this complexity would lead to a need for excessive personnel requirements to search, validate and input this information. Therefore comparison of energy efficiency levels between state facilities in the five categories previously presented is to be based upon energy usage adjusted for square footage and weather variations. In other words, facilities will be compared upon the basis of BTU consumption per square foot of conditioned space per degree day (heating and cooling degree days).

In addition to this method for ranking of facilities, it was desirable to produce outputs which detailed how facilities within a category performed on the basis of: BTU consumption, energy expenditures, and expenditures per square foot. Also a category average was desirable for each factor to see how a particular facility compares to the category average.

Development of an energy index based upon BTU consumption per square foot per degree day does not provide an all inclusive means of establishing how each possible variable may affect energy consumption. However, within the restraints imposed upon the research, and the high percentage of energy use affected by this energy index, it

is believed that an excellent means for comparing energy usage in similar state facilities has been developed. Additional methods are provided to enable comparison of energy usage between similar facilities as desired.

3.6 Development of Methods for Receiving and Validating Input Data

With the basic output features and means for comparing energy usage between facilities defined, necessary data inputs and methods for insuring data validity remain to be demonstrated. To enable generation of the previously described printouts, graphs, and comparison reports, input of relatively simple data for each facility being monitored is necessary. This input data includes: fuel unit consumption by fuel type, energy expenditures by fuel type, square footage of conditioned space, and degree day data including both heating and cooling degree days.

The first three types of data listed above are available from each facility. Prior to, and in anticipation of, conducting this research it was requested by the State Energy Conservation Team that each facility owned and operated by the State begin monthly tabulations of energy expenditures and fuel consumption levels by fuel

type [11]. Facilities were instructed to begin these tabulations with the first month of Fiscal 1986, or July 1985 (fiscal years run from July to June in Virginia state government). Instructions were provided to each recipient of the State Energy Conservation Manual [11] on the preparation of these monthly tabulations. The final result of these tabulations would be the completion of a monthly energy report, which would be returned to the State Energy Team. A copy of this monthly form is presented in Figure 7. In addition to this monthly tabulation, at the end of the fiscal year, annual summaries are required as well.

This method of receiving data for input into the EMRS is chosen for two basic reasons. First by involving each facility with tabulating monthly energy records, which were to be completed by designated facility energy managers, it is hoped that each facility will begin to track and analyze their own energy usage trends. Thus, facility personnel involvement, and hopefully interest in the statewide energy conservation program will be initiated. Second, data retrieval is limited to two available options. These options are to either receive facility energy reports as previously described or attempt

CURRENT YEAR
MONTHLY WORKSHEET FOR ENERGY CONSUMPTION
AUDIT FORM

FACILITY NAME (please enter for each sheet and be specific): _____

Person Submitting Form : _____ SCATS No. _____

MONTH: _____ YEAR : 19 _____

FACILITY TOTAL MONTHLY CONSUMPTION AND COSTS:

1. Fuel Oil # 1	_____ gals. x 136,000 = _____ BTU's	\$ _____
2. Fuel Oil # 2	_____ gals. x 139,000 = _____ BTU's	\$ _____
3. Fuel Oil # 4	_____ gals. x 145,000 = _____ BTU's	\$ _____
4. Fuel Oil # 5	_____ gals. x 147,000 = _____ BTU's	\$ _____
5. Fuel Oil # 6	_____ gals. x 150,000 = _____ BTU's	\$ _____
6. Natural Gas (M)	_____ cu ft x 1,020 = _____ BTU's	\$ _____
7. LP Gas	_____ gals. x 91,600 = _____ BTU's	\$ _____
8. Purchased Steam	_____ lbs. x 1,000 = _____ BTU's	\$ _____
9. Electricity	_____ kWh x 3,413 = _____ BTU's	\$ _____
10. Coal	_____ lbs. x 13,800 = _____ BTU's	\$ _____
11. Wood Chips/ Sawdust	_____ lbs. x 4,000 = _____ BTU's	\$ _____
TOTALS	(Add lines 1 through 11 above) _____ BTU's	\$ _____

(M) If bill gives gas consumption in CCF (hundreds of cu ft) multiply by 102,000 not 1,020. Likewise, multiply by 1,020,000 if units of consumption are MCF (thousands of cu ft).

See cover letter in front of Manual for those facilities which should submit a copy of this Monthly Worksheet (and Annual Worksheet) to:

State Energy Conservation Team
 Division of Engineering and Buildings
 805 East Broad St., Room 101
 Richmond, VA 23219

Figure 7. Facility Monthly Data Sheet

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retrieval of energy data from energy vendors supplying each facility. This would include vendors of electricity, fuel oil, propane, natural gas, wood, and coal to each facility. Since vendors have little to gain by providing such information and since a network of designated facility energy managers exists and was being utilized for other reasons on a continuing basis, the best available data source is decidedly each facility energy manager. This choice appears even more attractive when coupled with the task of requiring the hundreds of energy suppliers to state facilities to generate and present information on a regular basis that is intended to be utilized to decrease the vendor's sales. The final item required to complete input data, degree day information, is readily available from the National Weather Service located in Asheville, North Carolina. Since the state has been divided into six weather regions by the NWS, as depicted in Figure 6, monthly and annual reports were requested from each climatological station located in each region. From this data, each facility located in the respective weather region will have identical degree day data. Since these six regions are determined by assessing the variations in weather patterns throughout the state (by the National

Weather Service) this limitation of the system is certainly desirable over the prospect of retrieving weather data from each facility. This argument becomes clearer when assessing the fact that only facilities with central steam heating plants record such weather data and such records have been shown to be less than accurate on occasion.

Once energy data has been retrieved, it must be shown to be accurate. Data validation will be accomplished using two methods. First each facility's monthly energy report will be manually checked prior to data entry into the EMRS. Data will be assessed, noting previous months consumption records and by calculating fuel unit costs for each fuel reported. Questionable data will be noted and facility personnel supplying the information contacted for clarification. Once the EMRS is operational, printouts and graphs depicting fuel unit costs, and fuel consumption in units and BTUs for each fuel by month will present a second method of data validation. Only after data has been shown consistent, using these two methods, will printouts, graphs, and comparison reports be distributed to facilities, department and agency heads, and to branch secretaries.

3.7 Creation of the Division Diskette Structure

The first attempt at creating a workable EMRS for the State of Virginia involved investigation of creating a separate spreadsheet format for each set of similar facilities grouped into a common category (see Section 3.4). Each spreadsheet file would contain energy usage, square footage and weather data for each facility within the category. Also, each file would contain various program routines to generate the desired outputs. It was desired to create a spreadsheet file utilizing this format with program routines and data contained in one spreadsheet file, due to the simplicity of program development in this manner. Using this spreadsheet structure, program routines contained on one category spreadsheet would be very similar in nature to program routines contained in a different category spreadsheet. Use of this spreadsheet format, however, was soon determined to be non-feasible. The overriding cause for failure of this technique was the enormous amounts of Random Access Memory (RAM) required. With available computer hardware resources limited to 512 kilobytes (k) of RAM, a different technique would be necessary to develop a workable system.

The second, and ultimately successful, attempt at creating a statewide EMRS involved developing individual program files, with each program file responsible for generating a particular output or for performing a given task. In addition, program and data files were designed such that each category's set of files are contained on separate diskettes. However, each common program file on a category diskette would be similar to a program file contained on another category diskette. Also, data is designed to be stored in separate files including facility energy data files, a weather data file and a square footage data file. These data files are accessed by each program file only when necessary for task completion. Efforts have been focused to allow for creation of a combination of program and data files such that at any given time during system operation, RAM resources of 512 K will not be overrun. In order to access and manipulate data in a timely fashion, it is desirable to create data files which require the smallest amount of diskette storage space possible. All of the features described within this paragraph became known as, and is referred to as, Division Diskette Structure. In other words, each category of similar facilities is referred to as a division, and each

Division Diskette contains sufficient program and data files for operation of an EMRS for those facilities. Since it was only desirable to compare energy usage between similar facilities, this method is deemed appropriate and useful. Utilizing the Division Diskette method allowed for creation of a single Division Diskette, then making minor modifications to program files to create subsequent Division Diskettes. Each diskette contains entirely different facility data and square footage files.

It was determined that the division (category) with the largest number of facilities, and therefore, facility data files, would ultimately restrict the size of program and data files allowable. Once program files had been established, only a limited number of data files could exist on the same Division Diskette. However, each diskette was created such that additional facilities could be added if desired.

With these restrictions and overall system objectives in mind, and the idea of Division Diskettes firmly established, the task of creating a Division Diskette for the category with the largest number of facilities, Community Colleges (see Appendix A) was

undertaken. Additional Division Diskettes would be established through modifications made to the Community Colleges diskette.

3.8 Development of Data Files

The Division Diskette structure is divided into two distinct parts, data files and program files (See Figure 8; the files listed under Other are utilized by the data files during EMRS execution). Development of data and related files will be discussed in this section. Discussion of program and related files is presented in Section 3.9. It should be noted that the discussions in the next two sections assume a casual knowledge of the Symphony program language. Program use, however, does not require any knowledge of Symphony. Since this discussion is presented to explain the methods used to develop the EMRS that forms the basis for the research, it is left to the reader to refer to Symphony reference materials for ideas and terminology presented that are not fully understood. Also during the discussion that follows, all Symphony worksheet files are distinguished by being written in all CAPS, with no file extension (WR1) shown. Other files have extensions shown.

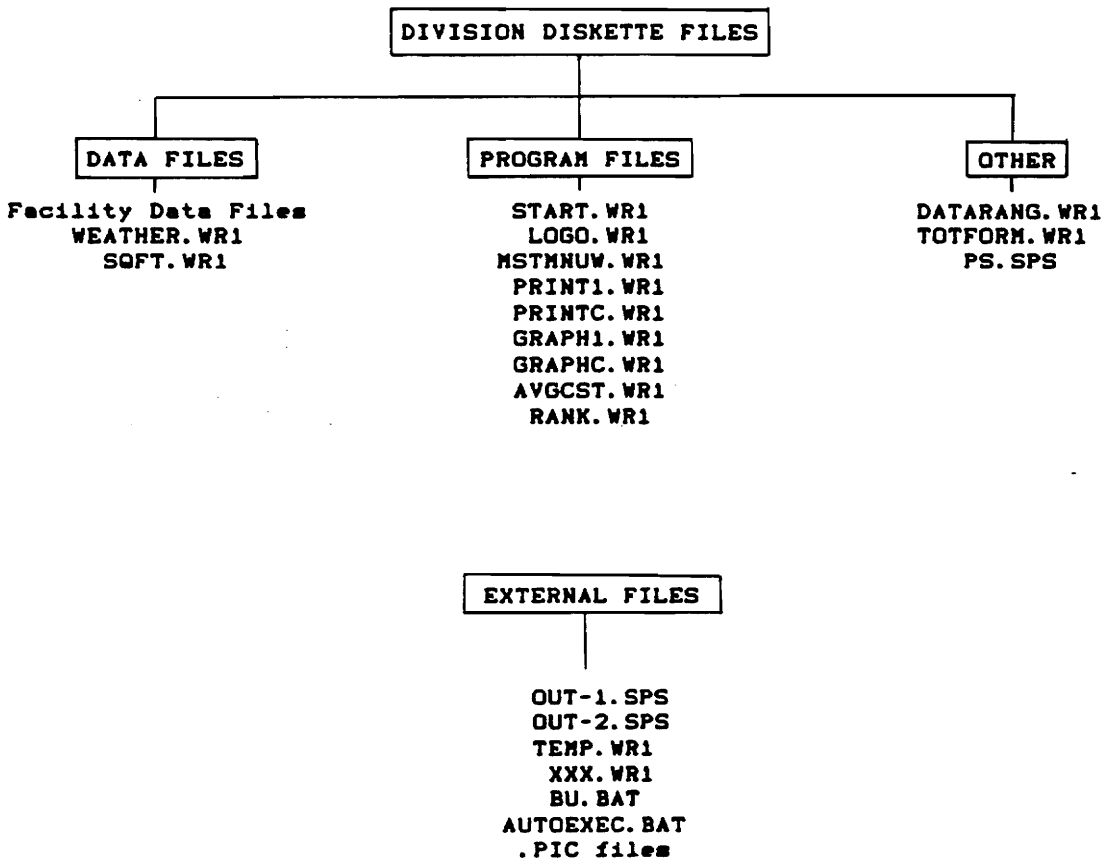


Figure 8. The EMRS Structure

In Section 3.2 a list of desirable outputs from the EMRS was established. To provide for generating these outputs several types of data are required. First and foremost, facility energy usage data must be available. This data includes a monthly tabulation of unit consumption and expenditures for the eleven fuels outlined in Figure 7. A method for accessing monthly figures as well as annual totals for any given year was necessary to provide for reasonable program run-time. The methods used to accomplish this are outlined later in this section. The second type of data required is facility square footage data. This information will be input into the system through annual reports provided by each facility similar to the monthly report shown in Figure 5. Finally, it is necessary to retrieve weather data - heating and cooling degree days - for each facility. As stated in Section 3.6, this information is available from monthly reports generated by the National Weather Service. Each of the three types of data discussed herein, is vital in the development of an effective EMRS. Methods used to create a Lotus Symphony file for each data type are presented next. Each file is broken down into its different spreadsheet areas (in Symphony these are referred to as "windows"). A

discussion as to the function of program routines ("macros" in Symphony) in each window is also provided. A typical facility energy data file is discussed first, followed by a discussion on the square footage file and weather data file.

In discussing facility data files, it is logical to begin with the first window that the user will see when such a file is accessed for input of data. For developing the system contained herein, it was desired to create a program that is aesthetically pleasing as well as functional. This provides for a more professional appearing program and is achieved by providing a smooth transition when moving from one file to another without the program appearing disjointed. This is accomplished through the use of the "Please Wait" or "Message" spreadsheet areas or windows. When accessing or leaving a file, this window is displayed on the monitor and the user only sees the message . . . Please Wait . . . on the screen. If this window were not used, the user would see a variety of cursor movements, macro commands and window transfers, which would confuse users of the EMRS developed if they were not familiar with Symphony. Once the Please Wait or Message window appears when accessing a facility data file

there is a brief pause then the user enters the data into the window referred to as the Main window.

The Main window was developed to allow the user to input unit consumption and expenditure data for each of the eleven fuel types. Once the Main window appears, column and row titles enable the user to readily input data for the desired month. Formulas for computing annual totals for each fuel are contained at the bottom of the Main window.

It is important to note that development of the facility data file format was dictated by the need for facility data files to consume a minimum of diskette storage space. This was desired for two reasons. First, data file access time from program files is proportional to data file size. Second, once program files had been established, only a limited number of facility data files would physically fit onto each Division Diskette. A review of the divisions created, as shown in Appendix A, indicates that the Community Colleges' division would require a minimum of thirty-three (33) facility data files. To allow for expandability in the number of facilities within each division, facility data files and program files would need to be developed to permit storage of a minimum of thirty-

three (33) facility data files on each Division Diskette. There is the need for storage of even more files than this to allow for addition of facilities to a division.

Efforts to reduce storage requirements began by identifying that storing formulas to maintain annual totals required greater storage space than storing only annual total values. This led to creation of the TOTFORM file. This file contains the formulas that calculate annual totals within the various facility data files. When storing the facility data file, annual total formulas are first converted to their respective values, then the data file is stored. When the facility data file is retrieved, program routines within the Macro window retrieve the formulas contained within the TOTFORM file and write them to the proper areas within the Main window of the facility data file. Using this approach, formulas for determining annual totals are stored in only one file, instead of being stored in each facility data file.

The Macro window referred to above also serves a second purpose. This window contains program routines that retrieve column and row titles from the DATARANG file. Before the facility data file is stored, column and row titles are erased to minimize storage requirements. In

addition, the relatively small program routines within the Macro window of the facility data file retrieve other program routines contained in the DATARANG file that are used to convert formulas to values, erase column and row titles, and store the data file. When the data file is stored, the smaller program routines (or macros) erase the much larger macros that are imported from the DATARANG file before the facility data file is stored. Erasing the larger macros before the data file is stored prevents storing the same macros over and over in each data file. These larger macros are stored only once in the DATARANG file, along with the column and row titles for each facility data file.

While efforts to limit the storage requirements of facility data files were tedious, they were necessary to provide a usable EMRS whereby all program and data files for one division were to be stored on one diskette. Without use of the techniques outlined above, including use of the TOTFORM and DATARANG files, each facility data file would have required approximately 62 K of diskette storage space. Input of ten years worth of data would have led to disk requirements of 70 K for each facility data file. This would have permitted storing just 17 data

files on a 1,200 K diskette with no additional storage space for program, square footage or weather files. The techniques outlined require use of only 18 K of storage space for a facility data file containing ten years worth of data. Thus, a net reduction in needed storage space of 74% was achieved while providing the key element to permit successful creation of the desired EMRS.

It was also necessary to create a means whereby monthly and annual data could be accessed by program files without requiring the importing of the entire facility data file into the program file. This was accomplished by creating a range name for each month and each annual total, including unit consumption and expenditure figures. Unit consumption and expenditure figures for the eleven fuels are given a range name in the following manner. For example, the spreadsheet area containing the monthly data for July, 1989 was given the range name JUL 89. Similarly, the cell locations containing annual totals for Fiscal 1989 were given the range name TOTALS 89. To allow for importing all twelve months of data and the annual totals at one time, if necessary, a third set of range names were created. As in the above two examples the twelve months of data and annual totals figures for Fiscal

1989 were given the range name 89. Other months and years were labeled with corresponding range names.

Facility data files were limited to ten years worth of data due to the diskette storage space restrictions. Fiscal years 1986 through 1995 are included on each facility data file with range names for monthly and annual totals for each of these fiscal years. Also each facility data file is labeled corresponding to the facility's FAACS tract number (see Appendix A). In this manner an exclusive file name can be created for any facility. As an example, the facility data files for the two Rappahannock Community College campuses, have been given two separate filenames of 278001 and 278002 (the hyphen symbol is not allowed in naming Symphony work files). The same method of naming facility data files is utilized for the remaining facilities and can be applied equally to those facilities added in the future.

After creating facility data files, including the creation of the DATARANG and TOTFORM files, it remained necessary to develop files for storage of square footage and weather data. Since these files would contain only input data and no formulas, no elaborate techniques were necessary to limit their storage requirements.

The file created on each diskette for storing of square footage data was aptly named SQFT. As is the case for facility data files, ten years worth of data can be stored within each SQFT file contained on each Division Diskette. Each SQFT file contains the annual average number of conditioned square feet for each facility within the particular division. Monthly tabulations were not utilized since the available square footage for the vast majority of facilities rarely changes more than once a year. It was the author's belief that monthly updates on square footage utilized would not effectively reflect the progressive increase in usage of new buildings or building areas that usually takes place when new construction projects approach completion. In addition, the increased storage requirements, 47.6 K for annual updates versus 571.2 K for monthly, clearly indicated the necessity for use of the format chosen.

To provide for accessing square footage data from within program files, each annual figure of square footage for a particular facility and year is labeled with a corresponding range name. For example, the square footage figure for Eastern State Hospital (FAACS Tract Number 704) for Fiscal 1985-86 is given the range name 704 - (85-86).

This technique is utilized to decrease program execution time versus importing the entire SQFT file into program files. The SQFT file also utilizes the Message window to provide for program continuity during entrance into and exit from the file.

Since only annual figures are utilized, a method was developed for those facilities whose square footage increases or decreases in a given year. The annual figure entered into the SQFT file is to be a pro-rated total of square footage utilized during the year. For example should Eastern State Hospital experience a growth from one million square feet, for July 1, 1985, through January 31, 1986, to 1.1 million square feet for February 1, 1986, to June 30, 1986, the following would be the input into range 704 - (85-86):

$$\frac{(1 \times 7) + (1.1 \times 5)}{12} = 1.0417 \text{ million square feet}$$

This technique provides an equitable solution to the inability to store monthly square footage figures.

The final type of data file created is the WEATHER file, which stores heating and cooling degree day information for each of the six weather regions outlined in Figure 6. Range names are again utilized to establish unique storage locations for each set of twelve months of

degree day information for each fiscal year and weather region. As an example, the WEATHER file range name for Lynchburg (Region 3) for Fiscal 1988-89 is labeled as 3-(88-89).

The obvious question that arises in discussing the WEATHER file is for what months are heating degree days used and which months are cooling degree days used. Obviously, heating and cooling energy loads are directly proportional to the temperature differential between indoor and outdoor conditions. Furthermore, most state-owned buildings utilize a heating system for one part of the year and a cooling system for another part of the year. Therefore, it is logical to assume that heating degree days would reflect the level of energy required during months of heating, and cooling degree days would provide identical information for months when cooling is necessary. However, there are months during which heating systems are utilized for one part of a month and cooling systems are utilized for the remaining days. This usually occurs during Spring and Fall. It is not feasible to account for such weather variations on a facility by facility level, ascertaining when heating and/or cooling occurs at each location. Therefore, a compromise was arrived upon that approximates

the effects of weather variations upon facility energy usage. Thus, the following approach establishes a method for comparing energy usage based on degree days. For each month the information indicated below would be entered into the appropriate WEATHER file cell location.

JAN - HDD	JUL - CDD
FEB - HDD	AUG - CDD
MAR - HDD	SEP - CDD
APR - HDD	OCT - CDD AND HDD
MAY - HDD AND CDD	NOV - HDD
JUN - CDD	DEC - HDD

HDD - Heating Degree Days

CDD - Cooling Degree Days

The heating and cooling degree days figures provided by the NWS are based upon a reference temperature of 65 degrees Fahrenheit. Use of a different reference temperature would have no effect on the total combination of HDD and CDD. Therefore, the total number of degree days (heating and cooling) is independent of the reference chosen and will not alter calculations of energy use per degree day. The techniques outlined above will give an

effective method of comparing the energy usage efficiency between similar facilities, even though approximations have been made to allow for ease in system development. These approximations, utilized uniformly throughout the EMRS, are reasonable based upon the research scope and should not produce an adverse effect upon system reliability.

As was the case for the facility data files and the SQFT file, the WEATHER file is arranged into several windows. The Message window again allows for smooth program operation as viewed by the user. A second message window, Message - 2, reminds the user to update WEATHER files on other Division Diskettes if changes have been made to the WEATHER file in use. The Macros window contains program routines utilized when the file is retrieved and stored. Finally, the Main window contains the degree day tabulations based upon previous instructions.

One final note regarding data files that applies equally to all program files as well. Each file developed contains two separate macros that are used either to begin file macro execution (display Message windows, retrieve information from other files, etc.) or to save the file in use. These macros are labeled with the range names, \Z to

begin macro execution, and \S to store files in use and continue in program use. The \Z macro is known as an auto-execute macro and is automatically executed when a file is retrieved. Since these range names are used within each data and program file they will not be discussed.

3.9 Development of Program Files

As previously outlined, system development depended upon creation of several individual program files. Each program file is responsible for creating a desired output, printout, graph, or for performing a necessary system task. The discussion on program files begins with an explanation of methods used to create files that start system operation. Next, the discussion proceeds to cover program files created for the purposes of: obtaining printouts; producing graphs; ranking facilities with respect to a chosen criterion; and obtaining miscellaneous energy usage information. The discussion proceeds in generally the same fashion as did the discussion on data files, with a discussion on windows in each file as well as a general explanation of program macros. Since all program files contain the auto-execute macro \Z, as discussed in the previous section, no further mention of this macro will be

made. Similarly, except as noted, all program files contain identical Please Wait or Message windows as contained in data files.

3.9.1 START and LOGO Files

The EMRS was developed in such a manner that no computer experience is necessary to operate the system. However, the user must input a set of very limited and simple keystrokes, which are clearly outlined in the User's Guide in Appendix B, to gain access to Lotus Symphony and the EMRS. Once access is gained to Symphony, the START file is retrieved which executes a simple macro contained within the Main window. This three line macro clears RAM by detaching any previously attached Symphony applications, updates the Symphony configuration file to make the A drive the current drive, and retrieves the LOGO file. The A diskette drive is utilized as the current drive since each Division Diskette is inserted into this drive. Execution of this macro is invisible to the user through use of the Blank window. This window is simply a blank document window which appears as a dark screen when made the current window. Macro execution is carried out, in a manner of a couple of seconds, resulting in automatic retrieval of the LOGO file.

The message that appears on the monitor when the LOGO file is retrieved shows the Department of General Services' name and outlines the creation date of the Division Diskette in use. The name of the Division Diskette in use is also displayed on the screen as an aid to the user, along with a note to press the Return key to continue. This display occurs automatically, shortly after the START file is retrieved by creating the LOGO file such that the Main window is the current window when the file is automatically retrieved by the START file.

When the Return key is depressed as prompted, the macro contained in the Macro window is executed. This program routine accesses the MSTMNUW file which serves as the program's master menu or central command point.

3.9.2 MSTMNUW File

The MSTMNUW file is the file around which all the program files revolve. This file determines which facility information will be generated for, what type of information will be generated or if data will be input into data files. Figure 9 displays the Master Menu window and the menu choices available to the user when this file is retrieved. Actions resulting from choosing a menu option

Change present facility name and number in use (given below) MENU
Facility Input Data Print Graph Rank Div/Fac Info HELP ! EXIT

MASTER MENU SCREEN

Move the cursor with the arrow keys
to the desired menu heading and press RETURN

PRESENT FACILITY NUMBER IS : 287

PRESENT FACILITY NAME IS : DABNEY S. LANCASTER COMMUNITY COLL

99

02-Dec-87 02:23 PM

Macro

Cap

Figure 9. The Master Menu Screen within MSTMNUW

are displayed immediately above the menu choices as shown in Figure 9 for the facility option. This menu structure is achieved by use of the {Menubranh} macro command which serves as the basis for creation of all interactive menus displayed during system operation.

The first available choice from the Master Menu Screen, as depicted in Figure 9, allows for inputting the present facility in use. This menu choice will shift program execution to the Facility Number window. This window allows input of the desired facility tract number (see Appendix A for a complete listing of tract numbers). Instructions are provided to the user, who enters a facility number and responds to a prompt asking if this is indeed the facility number desired. When this prompt is answered with a Yes (Y), program execution returns to the Master Menu Screen. Should the user input a facility number for a facility that is not contained on the particular Division Diskette in use, a message appears beside the title of Present Facility Name Is: in the Master Menu window. This message states that the facility number entered is improper for the diskette in use. Should the user not know which facility numbers are available, use of the HELP! menu option is provided.

The Help! menu choice transfers program execution to the Fac Names & Nos window. As the name depicts, all available facility names and corresponding FAACS tract numbers are displayed on the screen if the HELP! menu option is chosen. Available facilities are displayed in two orders: alphabetically by name and in increasing order by facility tract number. The user returns to the Master Menu Screen (Master Menu window) by pressing Return when the desired facility name or number is located. This is accomplished through a macro contained within the Mastermenu Macros window. Indeed, all available menu choices from the Master Menu Screen cause execution of macro routines contained within the Mastermenu Macros window. In addition to the menu choices and corresponding macros already discussed, macros within this window provide for: inputting data, printing reports, producing graphs, ranking facilities, obtaining miscellaneous energy information, or exiting the EMRS and returning to a blank Symphony worksheet. The Print and Graph menu choices branch to lower-level menus which ascertain which program file should be used in correspondence with the present facility in use. The Input Data option branches to a menu choice which allows inputting facility energy data, square

footage data, or weather data. Macros executed by choosing any of these lower-level menu options transfers program execution to the corresponding program or data file automatically. Choosing the Rank or Div/Fac Info options from the Master Menu Screen transfers program execution to the corresponding program file directly without the use of lower-level menus.

It is important to note that before program execution transfers to a separate program file or before the EMRS is exited, the MSTMNUW file and corresponding present facility name and number in use is saved onto the Division Diskette. This makes possible ready retrieval of facility energy, square footage, and weather data from the proper data file as needed within execution of macros contained in the remaining program files.

One final note regarding the use of the MSTMNUW file, in correspondence with program and data files alike, is that each program and data file returns program execution to the MSTMNUW file after creation of the desired output or input of desired data. Thus, the MSTMNUW file is the only available means for exiting the EMRS. This provides program continuity through a standardized operating method.

3.9.3 PRINT1 File

The PRINT1 file has been developed to print energy consumption information for a particular facility and single fiscal year. The format of the printout is selected by the user (See Section 4.4.1).

The Input window has been developed to enter the year for which information is desired. When the user chooses to printout information using the PRINT menu option, a choice of printouts is offered. The user may select to print information for the present facility in use (Facility Number window in the MSTMNUW file) for a single year to be chosen, or to printout a comparison analysis outlining the progression in energy usage by the present facility. The PRINT1 file is utilized for the first of these two choices. When accessed, the PRINT1 file imports the facility tract number in use from the MSTMNUW file. This is accomplished by the auto-execute macro contained within the Input window. Once the facility tract number has been imported a list of macro {If} statements determines the facility's name and weather region number. The weather region number is utilized later in the PRINT1 file to import the proper heating and cooling degree day information from the WEATHER file. After this information

has been retrieved, automatically while the user views the familiar . . . Please Wait . . . message, a prompt appears detailing the facility name and tract number for which information will be output. Next the fiscal year desired is entered and program execution is transferred to the Macros window.

Within the program routines contained in the Macros window, the user is queried by means of a menu created using the {Menubranchn} command whether the printout should include all twelve months and an annual total or an annual total alone. Next, macro commands within the Macros window provide for automatic program manipulation of the facility number, weather region number, and year input within the SQFT-DD-RETR window. These manipulations allow for retrieval of the correct square footage and weather data from the respective data file for the facility and year in question. Following these data retrievals printout of the desired information begins.

The commands to allow for automatic printing are again contained within the Macros window. Following a decision process, based upon the choice of a monthly and annual printout or an annual printout alone, energy usage data is retrieved and copied as necessary to the Monthly

Totals window. Program execution, from within the Macros window, first prints the proper heading onto the first sheet. If a month by month printout was chosen, the proper monthly heading detailing the facility name, fiscal year, month, and total degree days is printed. This monthly heading is contained in the Monthly Heading window. If the user has chosen to bypass the printing of twelve months of data and proceed directly to the annual printout, the Annual Heading window is utilized to print similar information, but also includes the facility number, square footage, and annual total of degree days. Before any printing occurs, the Message-2 window is displayed on the screen and provides instructions on the proper printer settings and use thereof. If a month by month printout has been selected, successive months of energy data are retrieved from the facility data file until all twelve months of data has been printed. The printout outlines unit consumption, expenditures, and BTU consumption by fuel and also includes monthly totals of expenditures, BTUs, expenditures per square foot, and energy usage (BTUs) per square foot per degree day. Finally, an annual totals printout with similar information is printed. Each annual totals printout contains a listing of the day's date and

time through printing of the information contained within the Date & Time window.

Once the annual totals printout has completed, program execution is transferred to the Master Menu Screen within the MSTMNUW file.

3.9.3 PRINTC File

The PRINTC file basically performs the same tasks as the PRINT1 file, except that the PRINTC file prints and compares information for the present, previous, and base (1985-86) years. This printout, comparing energy usage information, provides insight into the progression of each facility's energy conservation program. The choice to compare energy information for the present, previous, and base years allows the user to visualize changes from the past year as well as to note changes that have occurred since initiation of the EMRS. By use of several menus, the user may compare units consumed, dollars expended, BTU consumption, expenditures per square foot, and BTU consumption per square foot per degree day either on a monthly basis or by comparing end of year totals. Each printout was developed to allow for comparing the above information for each fuel type as well as utilizing

facility totals. (Facility totals of units consumed can not be printed).

The PRINTC file is so similar in operation to the PRINT1 file, that only a cursory discussion is presented outlining the major differences. The basic difference in the two program files is that the PRINTC file must retrieve energy usage, square footage and weather data for three years instead of one as in the PRINT1 file. Therefore, the macros within the Macros window are longer than those within the PRINT1 file. In addition, the Monthly Totals window in the PRINT1 file is replaced by three separate windows in the PRINTC file, the Units, Dollars, and Btu/Sqft/DD windows. This was necessary for obtaining the printouts in the desired format. Again, the Input, Monthly Heading, Annual Heading, Print Date, and Message-1 windows are almost identical to windows within the PRINT1 file. The added length of program routines and addition of windows are the reasons why the PRINTC file is over twice the size of the PRINT1 file (79,303 bytes versus 33,398).

Each printout from the PRINTC file (See Section 4.4.1) was developed using the following columnar format to allow for compact form and easy visualization of energy usage information. The first column lists the eleven fuel

types. The next three columns present the chosen energy information (units, dollars, BTU, dollars per square foot, or BTU per square foot per degree day) for the present, previous, and base years. The next four columns detail the differences between the present versus the previous and the present versus the base years, showing numerical and percentage changes for each fuel. As applicable, the last line of each PRINTC printout outlines annual totals. The sample printouts presented in Section 4.4.1 will allow for a clearer understanding of the printout capabilities of the statewide EMRS, for both the PRINT1 and PRINTC files.

3.9.5 GRAPH1 File

The GRAPH1 file has been developed to allow for obtaining identical information available as outlined in the PRINT1 file in graphical format rather than in printout form. The type of graph created is selected by the user through use of menu choices (See Section 4.4.2).

Program execution in the GRAPH1 file begins by entering the Retrieve window. Within this window, the facility name and number is imported from the MSTMNUW file. To save diskette storage space, as previously described for the facility data files, only a small portion

of the formulas utilized within the GRAPH1 file are stored within the file itself. Macros within the Retrieve window use the {Menu} Copy command to copy the necessary formulas to the proper cell locations. These formulas are utilized to calculate units, expenditures, energy costs per square foot, BTU consumption, and BTU consumption per square foot per degree days.

The user is next prompted by the Any Year window for the fiscal year that the graph generated will be based upon. These macro commands, however, are located in the Choice window. Once the correct fiscal year is entered, menu choices using the {Menubranchn} command allow the user to select the type of graph to be created. The menu choices and commands are contained within the Choice window. The user may select to generate a graph depicting various energy usage information (units, dollars, dollars per square foot, BTUs, BTU per square foot per degree day) for a particular fuel type or for all fuels combined. In addition, pie graphs depicting the breakdown in energy usage by fuel type can be created on the basis of BTUs or expenditures. All of the menu choices necessary to define the graph type desired are selected using menus created from commands contained within the Choice window. Once the

proper graph type has been selected, program execution transfers to the Graph window and specifically to the Graph Line range.

The macros contained within the Graph window retrieve facility energy data, square footage data, and weather data as necessary for creation of the graph type selected. These various types of data are retrieved and written to the proper area within the Basic Data window. Before data is retrieved, however, the macro contained at the range name location Graph Line determines if data for the year in question has been imported previously. If not, data is retrieved as described above. If data has been retrieved previously, or once data retrieval is completed, program execution is transferred depending upon the type of graph to be generated. If a pie graph has been selected, program execution transfers to the Graph Pie range. If a line graph has been selected, program execution is transferred to the Fuel Decision range.

Creation of a pie graph begins by creation of the graph titles utilizing commands immediately following the Graph Pie range. These graph titles are positioned within the Pie Graph Yr window, which is a Document window. Following title creation, the fuels utilized by the

facility are determined by noting which fuels have positive expenditures for the year in question. If expenditures are determined positive within the cell locations for annual totals in the Monthly Data window, legends for these fuels are created using {If} commands. The Monthly Data window contains the formulas for calculating the various types of energy usage information. As noted, only a small portion of the formulas necessary to determine these values are stored within the GRAPH1 file. Macros within the Retrieve window copy these formulas to the proper cell locations allowing for calculation of energy usage information for all twelve months and the annual totals. Initially, formulas are stored for July only, but are copied to the remaining months. Once pie graph legends have been created, program execution is transferred to the Fuel Decision range, as it is for line graphs as previously described.

Macro commands at this location create a second graph title depicting the fuel type. For a pie graph this title is labeled as Facility Totals - All Fuels. This title is also utilized for line graphs showing a combination of values for all fuels. If a particular fuel has been selected, the various {If} statements determine

the fuel name and create a graph title based upon selected information. Before the graph is displayed on the screen, the Graph Message window is utilized to display a message that informs the user to press return after viewing the graph. The graph can be displayed as long as desired, and will continue to be displayed until the return key is pressed. This function is inherent within Symphony and is not programmed using system macros. The proper graph is displayed utilizing the graph settings name corresponding to the graph selected using the menu choices available. When selecting the graph type desired, a particular cell location within the Sqft-DD window stores these choices and allows selection of the proper graph settings sheet name for graph creation. Each graph settings sheet contains the information allowing for display of the desired information. For example, the graph settings sheet used to create a graph for Number One fuel oil is different from the sheet used to create a graph for Number Two fuel oil, even if both graphs depict units consumed by month for a particular fiscal year. In addition, each graph settings sheet contains information regarding x and y axes titles and type of graph (line versus pie). The GRAPH1 file contains sixty-one different graph settings

sheets. This number is arrived at by noting that there are five basic types of information that can be displayed or graphed for each of the eleven fuel types. These include units, dollars, BTUs, dollars per square foot, and BTU per square foot per degree day. This accounts for fifty-five of the sixty-one settings sheets. There are four setting sheets for facility totals graphs since units can not be displayed for this type of graph. Finally, there are two types of pie graphs, one for displaying fuel usage by expenditures for each fuel and a second graph showing fuel usage in BTUs.

Once the user is finished viewing the graph on the monitor, messages contained within the Save Yes-No and Save Pie windows permit storing the graph .Pic file which is used in generating a hardcopy of the graph displayed. Choosing to create a .Pic file transfers execution to a macro which stores the .Pic filename entered interactively, as well as storing the present GRAPH1 file onto the fixed disk within the EMRS sub-directory. This file is stored as TEMP.WR1 and allows for generation of a hardcopy of the graph created without storing the file onto the Division Diskette in use. Regardless of whether the .Pic file is created or not, program execution is transferred to the

initial menu choice contained in the Graph window. The menu choice allows for generating subsequent graphs or returning to the Main Menu Screen within the MSTMNUW file. Procedures for generating a hardcopy of any graph created are outlined within the User's Guide in Appendix B.

3.9.6 GRAPHC File

The GRAPHC and GRAPH1 files are similar in nature, just as are the PRINT1 and PRINTC files. The GRAPHC file creates graphs comparing present, previous, and base year values just as the PRINTC file creates printouts of this information. Again, these comparison graphs are utilized to evaluate the effectiveness of each facility's energy conservation program. As is the case with the PRINTC file, the GRAPHC file is so similar in nature to the GRAPH1 file, that only a cursory discussion is presented outlining the differences between the GRAPH1 and GRAPHC files.

The first major difference in the two graphing files is that the user inputs the year to be used as the present year in the GRAPHC file. The year used for the previous year is calculated based upon the input for the present year. The base year is a fixed value and is always Fiscal 1985-86. The user inputs the present year in the

Input window just as input of any given year is performed in the GRAPH1 file.

A second major difference between the two graphing files is that data (facility, square footage, and weather) must be retrieved for three different years within the GRAPHC file. This noticeably slows down program execution. Likewise there are three sets of formulas, created by {Menu} Copy commands, that represent the five types of energy usage information for the three years in question. These formulas again are stored within the Monthly Data window. Values calculated by these formulas are utilized by the fifty-nine different graph settings sheets to display and generate hardcopies of graphs desired. The number of settings sheets falls from sixty-one as in the GRAPH1 file, since the two pie graphs available in the GRAPH1 file cannot be generated within the GRAPHC file.

All remaining program routines within the GRAPHC file are very similar to those found in the GRAPH1 file. The sample graph outputs in Section 4.4.2 will allow for a better understanding of the graphical capabilities of the EMRS developed.

3.9.7 AVGCST File

The AVGCST file was designed to allow the user to obtain various energy information either for one facility within a division or for all facilities within a division combined. This information includes monthly tabulations of: fuel unit costs, expenditures, and fuel costs per million BTUs for each of the eleven fuel types. In addition, annual totals or averages are included within the printout (See Section 4.4.4).

Program execution begins with execution of the auto-execute macro contained in the Macros window. As in the print and graph files, the facility name and number are retrieved for the present facility in use within the MSTMNUW file. Next, formulas contained within the Retrieve window are copied to various cell locations for calculation of the necessary information. Within the Retrieve window two formulas, used to calculate fuel unit costs and cost per million BTU, are copied to 143 different locations each. Use of this macro allows storing two formulas in two cell locations, rather than 246 formulas in 246 cell locations. Thus, necessary diskette storage space is held to a minimum. Following this copying technique, the present facility number in use is copied to the Fac No window, and is also utilized within the Fac-Div window.

The Fac-Div window displays a message asking what type of computation is to be performed. A menu appears at the top of the screen which is created using the {Menubranh} command within the Macros window. The choices include compiling information for a particular facility or for the entire division. Next the user is queried as to what information is to be compiled (units, dollars, unit costs, or costs per million BTU) from within the Print Choice window. Once these two menu choices have been made, execution transfers to the Year window where the user inputs the year for which information is to be compiled.

Following these routines, data is retrieved from the necessary facility data file(s) and is inserted into the proper cell locations within the Retrieve window. If information is being tabulated for a single facility this data is retrieved and program execution continues. If information is being tabulated from all facilities within the division, use of the {Menu} Combine Add commands allows adding consumption and expenditure data retrieved from each facility data file to obtain a division total. Formulas contained in the Retrieve window calculate unit costs and costs per million BTUs for each fuel over twelve months and for the end of year total.

Depending upon the type of printout chosen, data or calculated values from the Retrieve window are copied to the Printout window. Within the Printout window, macros erase all values equal to zero or for cell locations where an ERR (error) message occurs. These two values (zero or ERR) occur when the fuel type is not used by the facility or division. Erasing these null values creates a clearer, easier to understand printout. An example printout from this file is also presented in Section 4.4.4.

Once all data has been copied and null values erased as necessary, printing of the data is accomplished using the Sideways software. Use of this software requires creation of configuration files to specify how the data is to be printed (character size, margins, borders, etc.). These configurations are contained within the OUT-1.SPS and OUT-2.SPS files contained on the EMRS fixed disk sub-directory. These files are externally stored to prevent using limited diskette storage space. A third .SPS file, PS.SPS is created by the Sideways software the first time this software is utilized.

After information has been printed, the user is asked whether to print additional information for a

particular facility, for the entire division, or whether to return to the Master Menu Screen within the MSTMNUW file.

3.9.8 RANK File

The final program file created is the RANK file. As the name suggests, the RANK file is used to rank facilities within a division according to one of several criteria. The most important criterion is the Energy Index developed, or BTU per square foot per degree day. In addition, there are several other criteria that can be used to rank facilities. These include ranking in order of facility number, alphabetically by facility name, by annual expenditures for energy, by annual BTUs consumed, and by expenditures per square foot (See Section 4.4.3). These additional methods allow ranking facilities based upon the needs of various persons using the EMRS. This would include facility business managers, agency and department heads, and branch secretaries.

The RANK file begins execution within the Macros window by processing the auto-execute macro. This macro contains a command that displays the Year window and requests the user to input the fiscal year for which information is to be tabulated. Next, the Choice window is

displayed that permits choosing the criterion upon which to rank the facilities. In addition, a message is displayed detailing how the printer should be adjusted.

Once the desired criterion is chosen, facility energy usage, square footage and weather data is retrieved and written into the proper cell locations within the Retrieve window. Once data has been retrieved for the first facility, calculations are performed to determine annual BTU consumption, expenditures per square foot and BTU consumption per square foot per degree day. All pertinent information for the first facility within the division is copied to the proper Database window cell locations. This process is repeated until all information for each facility within the division has been compiled within the Database window.

This compilation of data creates a database within the Database window with the following column headings for each facility: facility number, facility name, expenditures for energy, BTUs consumed, facility square footage, facility degree days, BTUs per square foot per degree day, and energy expenditures per square foot. In addition, a row at the bottom of the database totals appropriate columns. When the user selects how to rank

these facilities, using the previously mentioned menu choices, a routine establishes that choice as the database first sort-key. Thus, facilities are then ranked on the basis of the column (sort-key) selected by the user. Once this sorting process is completed, a printout is created showing the information described above, with the facilities ranked for the column selected. An example printout from the RANK program file is included in Section 4.4.3.

Once the printout has completed, the user is queried by display of the Sort Again window as to whether or not to resort using a different criterion. If the user selects to resort, a second printout is produced without retrieving data a second time by utilizing the existing database. If the user selects not to resort the facilities, macros within the Macros window return the user to the Master Menu Screen within the MSTMNUW file.

3.10 Development of External Files

During development of the AVGCST, GRAPH1 and GRAPHC program files, it became necessary to develop several essential non-program files. These non-program files, however, were necessary to allow for proper operation of

the program files described. These files are stored externally from the Division Diskette, on the EMRS fixed drive sub-directory, to allow for as much storage space on the Division Diskettes as possible.

Two of these external files, OUT-1.SPS and OUT-2.SPS, were discussed previously in Section 3.9.8. These files allow for printing the desired information, chosen from within the AVGCST file, in an organized, repeatable fashion using the Sideways software. These files specify the printout margins, character sizes, borders, etc., associated with the Sideways printout created by the AVGCST file. Printing the information in this manner allows the user to readily follow trends in energy usage information printed, from month to month. This will become more evident when the AVGCST example printout is presented in Chapter IV. Two additional files are classified as external files. These are the TEMP.WR1 and XXX.XXX files. Both of these files are used in conjunction with the GRAPH1 and GRAPHC files. During execution of these two program files, when the user chooses to produce a hardcopy of a graph created, the TEMP file is used to store the graph image created. This is accomplished in Symphony in two steps. First, the user is queried for a .PIC filename into

which the current graph settings sheet values will be stored. However, to produce a graph after exiting Symphony and entering the PRINTGRAPH program, the entire Symphony worksheet file, (in this case GRAPH1 or GRAPHC), must be saved as well. Since it is not desirable to alter the composition of the GRAPH1 or GRAPHC files, as they exist on the Division Diskettes, it is necessary to save the worksheet using an alternate filename. Thus, the program macros automatically save the present worksheet and .PIC graph settings sheets using the TEMP filename onto the EMRS fixed disk sub-directory.

The XXX.XXX file is used in conjunction with the BU.BAT and TEMP files. The BU.BAT file provides a means for easily backing up each Division Diskette without the user needing to know the necessary MS-DOS commands. As outlined in the User's Guide in Appendix B, the user simply types BU, presses return, and changes the diskette in Drive A as prompted to produce Division Diskette backups. During the backup procedure, the files contained on the Division Diskette are copied onto the fixed disk drive sub-directory which contains the external files, including the TEMP.WR1 file. After all Division Diskette files are copied onto the fixed disk, the backup diskette is inserted into Drive

A. Next, all .WR1 files are copied from the fixed disk to the backup diskette. To prevent copying the TEMP file onto the backup diskette, which would consume over 75 K of limited diskette storage space, the TEMP file is renamed XXX.XXX prior to this copying process. To allow for proper EMRS execution the XXX.XXX file on the EMRS fixed drive sub-directory is renamed to its original TEMP filename after the backup process is completed. This is necessary because when either of the GRAPH1 or GRAPHC files and related .PIC graph settings sheet are stored using the TEMP filename, the Symphony macros created assume that the TEMP file already exists and will be updated.

One final external file that exists is the EMRS sub-directory AUTOEXEC.BAT file. This file carries out only one specific task, which is to erase all existing .PIC files contained on the EMRS fixed disk sub-directory. This AUTOEXEC.BAT file can be executed at any time to clear this sub-directory of .PIC files should storage space become limited.

CHAPTER IV
RESULTS AND ANALYSIS

4.1 EMRS Structure

This chapter presents examples outlining the various capabilities of the EMRS developed. An overview of the Master Menu hierarchy is presented, along with a listing of menu choices from within each program file. Representative outputs from each program file provide the reader with a clearer understanding of the EMRS and its capabilities. A review of necessary data inputs and examples from each data file are also given. The reader is also presented with an analysis of the system developed with respect to expandability, maintainability and reliability. A comparison between the EMRS developed and the CARS sub-program for tracking energy expenditures is also presented at the conclusion of Chapter IV.

Before discussing the capabilities of the EMRS developed and presenting example outputs, it is appropriate to return to the listing of the EMRS's data and program files as well as external files. This listing was presented in Figure 8. Each Division Diskette developed contains the structure as depicted in the upper portion of this figure. As previously noted, all facility data files and the square footage data file differ between Division

Diskettes. Each weather data file, however, is identical on each diskette. Program files are basically the same on each Division Diskette, except for various {If} statements containing facility tract numbers, facility names, and facility weather regions. External files are contained on the EMRS fixed disk drive sub-directory. Any graph settings sheet files, .PIC files, created during system execution are also stored on the fixed disk drive.

It should be noted that it is not possible to present a detailed program listing for each of the files which make up the EMRS. This listing, due to the spreadsheet and window techniques utilized, is approximately five-hundred (500) pages in length. Similarly, a presentation of all possible printouts and graphs would consume over one-hundred and sixty pages (160). Therefore, the example outputs presented represent only a small percentage of available outputs, however, the Master Menu hierarchy and program file menu choices presented next will allow the reader to grasp the full capabilities of the EMRS developed.

4.2 Master Menu Hierarchy

The menu choices available from within the Master Menu Screen, as outlined in Section 3.9.2, enable

accessing the various data and program files. This hierarchy is illustrated in Figure 10. Each of the menu choices outlined transfers program execution to the files depicted or performs the task indicated. A discussion of each program file's menu choices and example outputs are presented in the Section 4.4.

An example of the appearance of each data file and the menu choices available when choosing the Input Data option are presented in the next section.

4.3 Data File Examples

As shown in Figure 10, choosing the Input Data option from the Master Menu Screen allows the user to access and edit the available data files. The actual menu choices available by choosing the Input Data option are shown in Figure 11. Examples illustrating the appearance of each type of data file are presented in Figures 12, 13, and 14. The examples shown have been created for illustrative purposes only and do not reflect actual facility, weather, or square footage data. In these and other examples presented within this chapter, the Division Diskette for the Department of Visually Handicapped was utilized (see Appendix A).

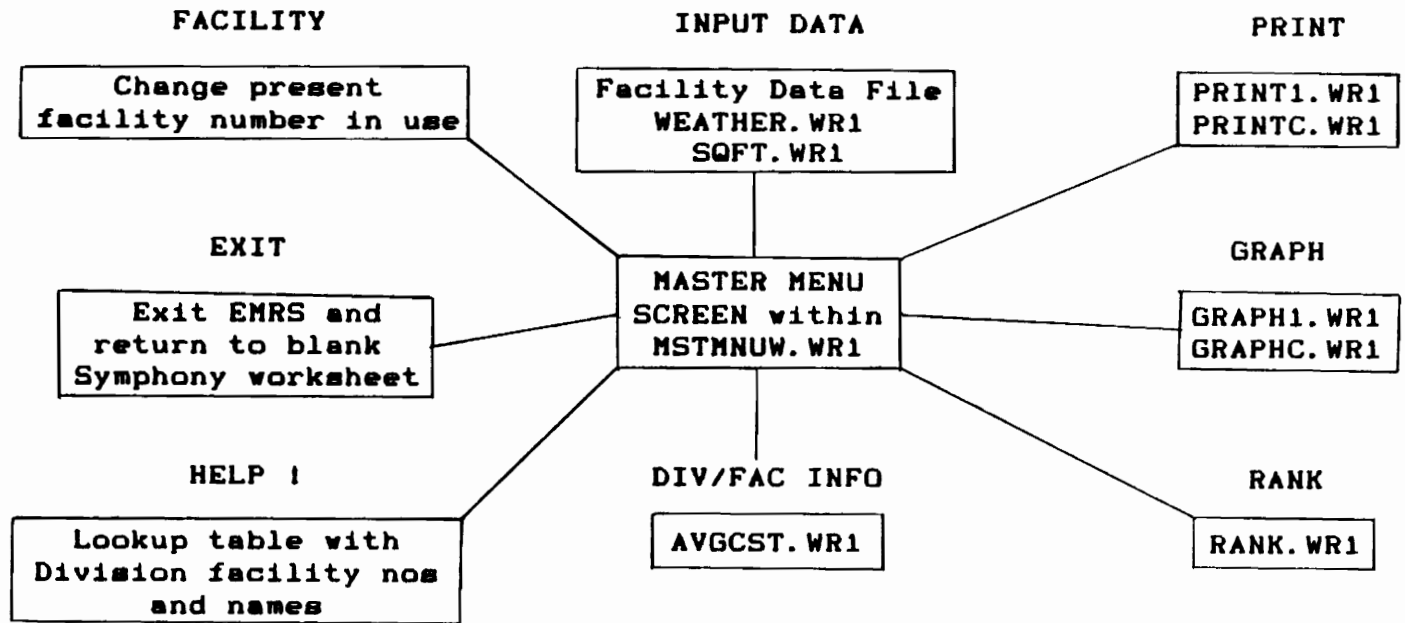


Figure 10. The Master Menu Hierarchy

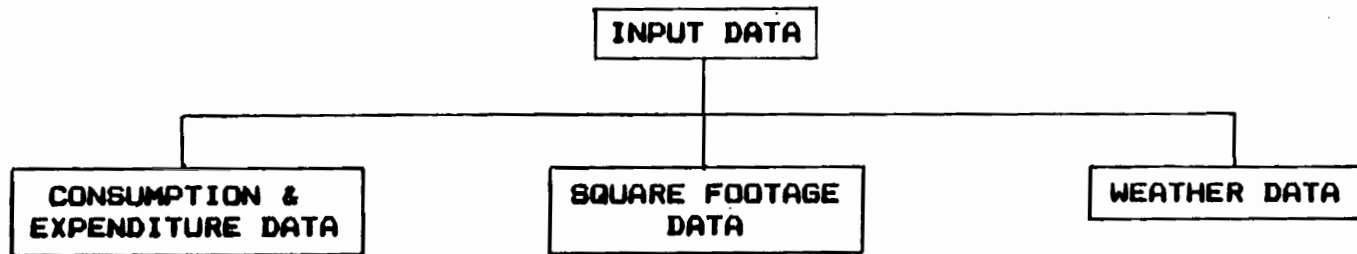


Figure 11. Input Data Menu Options

	A	B	C	D	E	F
1				BASE YEAR	FY 1985-86	
2	AGENCY NO & NAME-->			263	REHABILITATION CENTER F/T BLIND	
3				EXAMPLE ONLY		
4	PRESS ALT-S TO SAVE					
5	DATA AND RETURN TO					
6	MASTER MENU SCREEN					
7						
8				UNITS		DOLLARS
9			JUL 85			
10	OIL #1-	gal				
11	#2-	gal				
12	#4-	gal				
13	#5-	gal				
14	#6-	gal				
15	N GAS-	mcf				
16	LP GAS-	gal				
17	STM-	1000 #				
18	ELEC-	kwh		98,123.00		\$5,126.24
19	COAL-	ton				
20	WOOD-	ton				

97

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MAIN

Figure 12. Example Facility Data File

D
E16:

SHEET

	A	B	C	D	E
1					
2	SQUARE FOOTAGE OF AGENCIES				
3	FROM ANNUAL REPORTS FILED TO ENERGY TEAM				
4					
5	PRESS ALT-S TO SAVE AND RETURN				
6	TO THE MASTER MENU SCREEN				
7			Other Years	----->	
8					
9					
10			FACILITY		BASE YR
11			NUMBER		FY 85-86
12	-----				
13	REHABILITATION CENTER FOR THE BLIND		263		40,000
14	VA INDUSTRY FOR THE BLIND - CHARLOTTESVILLE		702003		100,000
15	VA INDUSTRY FOR THE BLIND - RICHMOND		702002		135,000
16	VISUALLY HANDICAPPED, DEPT OF - HEADQTRS		702001		75,000
17					
18					
19					
20					
					MAIN

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Figure 13. Example Square Footage Data File

	A	Z	AA	AB	AC
1	WEATHER DATA FILE				
2					
3					
4				OTHER REGIONS >>>>>>	
5					
6	PRESS ALT-S TO SAVE			REGION 3 LYNCHBURG	
7	AND RETURN TO THE				
8	MASTER MENU SCREEN				
9					
10				BASE YR	
11				FY 85-86	FY 86-87
12					
13	JUL			215	258
14	AUG			229	300
15	SEP			266	255
16	OCT			359	301
17	NOV			360	278
18	DEC			450	543
19	JAN			500	439
20	FEB			789	800
					MAIN

12-Dec-87 01:29 PM

Figure 14. Example Weather Data File

4.4 Program File Examples

In this section complete menu options used to access program files are outlined. Menu choice outlines and example outputs from each program file are also presented to help the reader understand the capabilities of the EMRS developed. Only a brief sampling of outputs possible from each program file are presented due to space restrictions. It should again be noted that outputs (printouts and graphs) presented are for example purposes only and do not represent actual facility or division data.

4.4.1 The PRINT Menu Option

Choosing the PRINT menu option from within the Master Menu Screen will allow creating either a single-year (PRINT1) or three-year comparison (PRINTC) printout. Available printout options are depicted in Figure 15. Example printouts are presented in Figures 16 through 19.

4.4.2 The GRAPH Menu Option

Choosing the GRAPH menu option from within the Master Menu Screen will enable the user to choose either a single-year (GRAPH1) or three-year comparison (GRAPHC) graph. Available graphing options are depicted in Figure 20. Example graphs are presented in Figures 21 through 26.

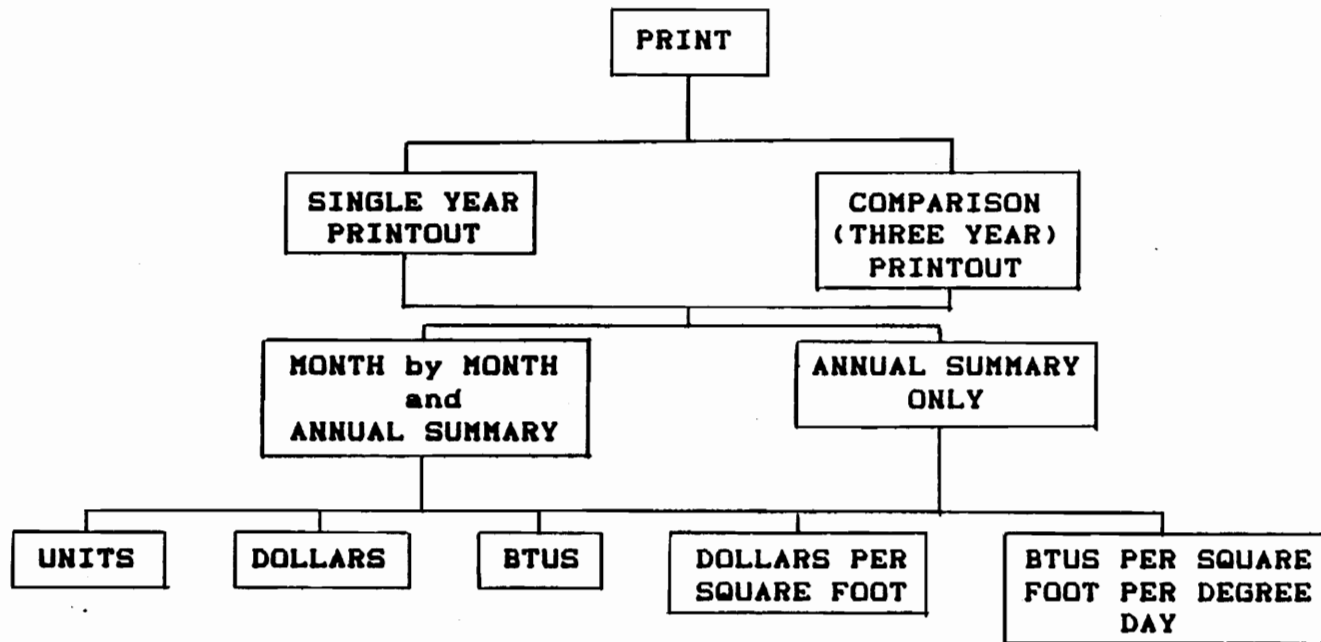


Figure 15. Printout Menu Options

REHABILITATION CENTER FOR THE BLIND

FISCAL YEAR : (85-86)

```
*****
*
*           MONTH : JUL                DEGREE DAYS :    215 *
*
*****
```

FUEL & UNITS	UNITS CONSUMED	COST	BTU'S CONSUMED (Thousands)
#1 OIL (gal)			
#2 OIL (gal)			
#4 OIL (gal)			
#5 OIL (gal)			
#6 OIL (gal)			
NAT GAS (mcf)			
LP GAS (gal)			
PUR STM (1000 #)			
ELECTRIC (kwhr)	98,123.0	\$5,126.24	334,894
COAL (tons)			
WOOD (tons)			
*** TOTALS ***		\$5,126.24	334,894

ENERGY COSTS PER SQUARE FOOT: \$0.128

BTUS PER SQUARE FOOT PER DEGREE DAY: 38.941

Figure 16. Example PRINT1 Month by Month Printout

ANNUAL SUMMARY

```

*****
*
* FACILITY NAME - REHABILITATION CENTER FOR THE BLIND *
*
* FACILITY NUMBER - 263 *
*
* SUMMARY FOR FISCAL YR - (85-86) *
*
* SQUARE FOOTAGE FOR FISCAL YR - 40,000 sq. ft. *
*
* TOTAL DEGREE DAYS FOR FISCAL YR - 4,024 *
*
*****
    
```

FUEL & UNITS	UNITS CONSUMED	COST	BTU'S CONSUMED (Thousands)
#1 OIL (gal)			
#2 OIL (gal)			
#4 OIL (gal)			
#5 OIL (gal)			
#6 OIL (gal)			
NAT GAS (mcf)	8,503.0	\$26,831.37	8,673,060
LP GAS (gal)			
PUR STM (1000 #)			
ELECTRIC (kwhr)	1,105,364.0	\$57,019.74	3,772,607
COAL (tons)			
WOOD (tons)			
*** TOTALS ***		\$83,851.11	12,445,667

ENERGY COSTS PER SQUARE FOOT: \$2.096

BTUS PER SQUARE FOOT PER DEGREE DAY: 77.321

PRINT DATE : 12-Dec-87

Figure 17. Example PRINT1 Annual Printout

MONTHLY COMPARISON PRINTOUT

REHABILITATION CENTER FOR THE BLIND

PRESENT FISCAL YEAR : 87-88

MONTH OF : JUL

FUEL	EXPENDITURES PRESENT YEAR	EXPENDITURES PREVIOUS YEAR	EXPENDITURES BASE YEAR (FY 1985-86)	PRESENT YEAR vs. PREVIOUS YEAR		PRESENT YEAR vs. BASE YEAR	
				DIFFERENCE (EXPENDITURES)	% CHANGE	DIFFERENCE (EXPENDITURES)	% CHANGE
#1 OIL							
#2 OIL							
#4 OIL							
#5 OIL							
#6 OIL							
N GAS							
LP GAS							
STM							
ELEC	\$4,664.51	\$4,541.51	\$5,126.24	\$123.00	2.71%	(\$461.73)	-9.01%
COAL							
WOOD							
TOTALS	\$4,664.51	\$4,541.51	\$5,126.24	\$123.00	2.71%	(\$461.73)	-9.01%

NOTES: N/C - Unable to calculate number

() Denotes a negative number

Figure 18. PRINTC Monthly Comparison Printout

ANNUAL COMPARISON PRINTOUT

REHABILITATION CENTER FOR THE BLIND

PRESENT FISCAL YEAR : 87-88

FUEL	PRESENT YEAR	PREVIOUS YEAR	BASE YEAR (FY 1985-86)	PRESENT YEAR vs. PREVIOUS YEAR		PRESENT YEAR vs. BASE YEAR	
	BTU (000's)	BTU (000's)	BTU (000's)	DIFFERENCE BTU (000's)	% CHANGE	DIFFERENCE BTU (000's)	% CHANGE
#1 OIL							
#2 OIL							
#4 OIL							
#5 OIL							
#6 OIL							
N GAS	8,469,060	8,600,640	8,673,060	(131,580)	-1.53%	(204,000)	-2.35%
LP GAS							
STM							
ELEC	3,714,863	3,652,511	3,772,607	62,352	1.71%	(57,745)	-1.53%
COAL							
WOOD							
TOTALS	12,183,923	12,253,151	12,445,667	(69,228)	-0.56%	(261,745)	-2.10%

NOTES: N/C - Unable to calculate number

() Denotes a negative number

Figure 19. PRINTC Annual Comparison Printout

PRINT DATE : 12-Dec-87

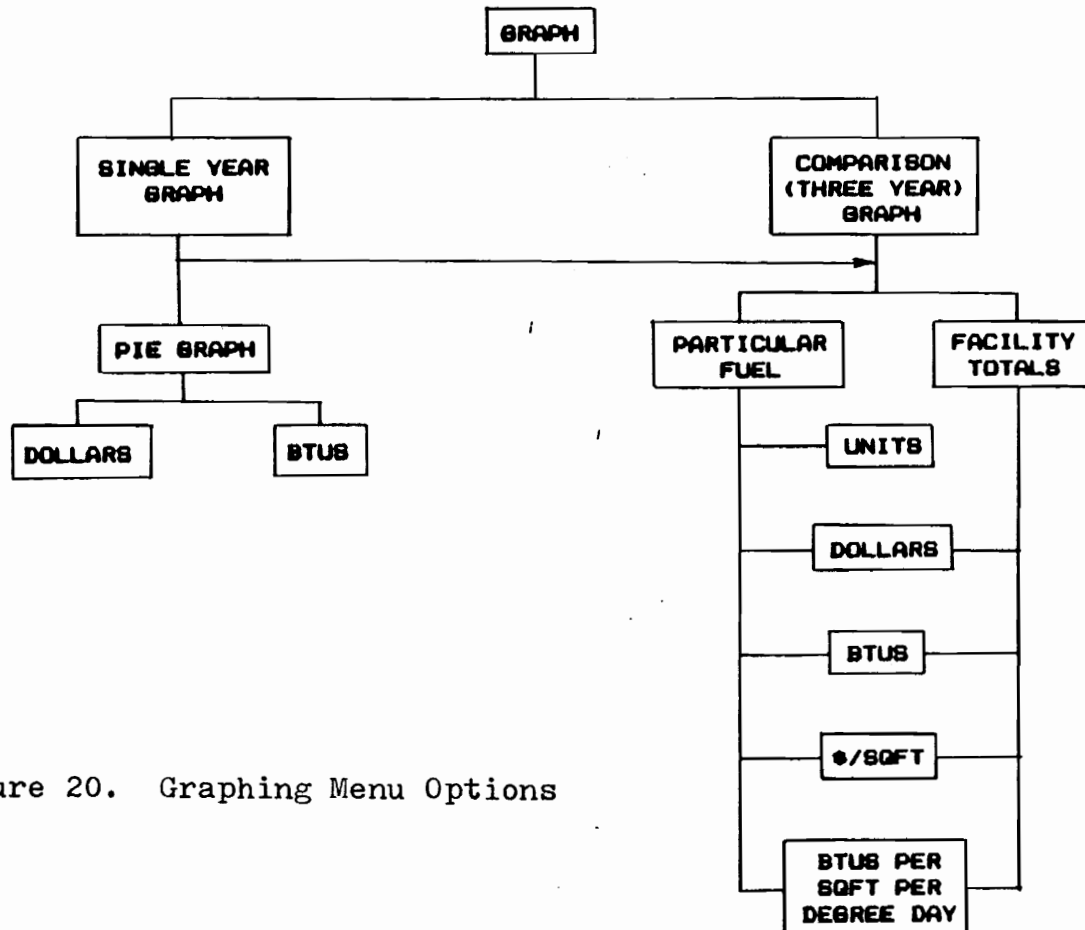


Figure 20. Graphing Menu Options

REHABILITATION CENTER FOR THE BLIND
EXPENDITURES FOR ENERGY: FY 1986

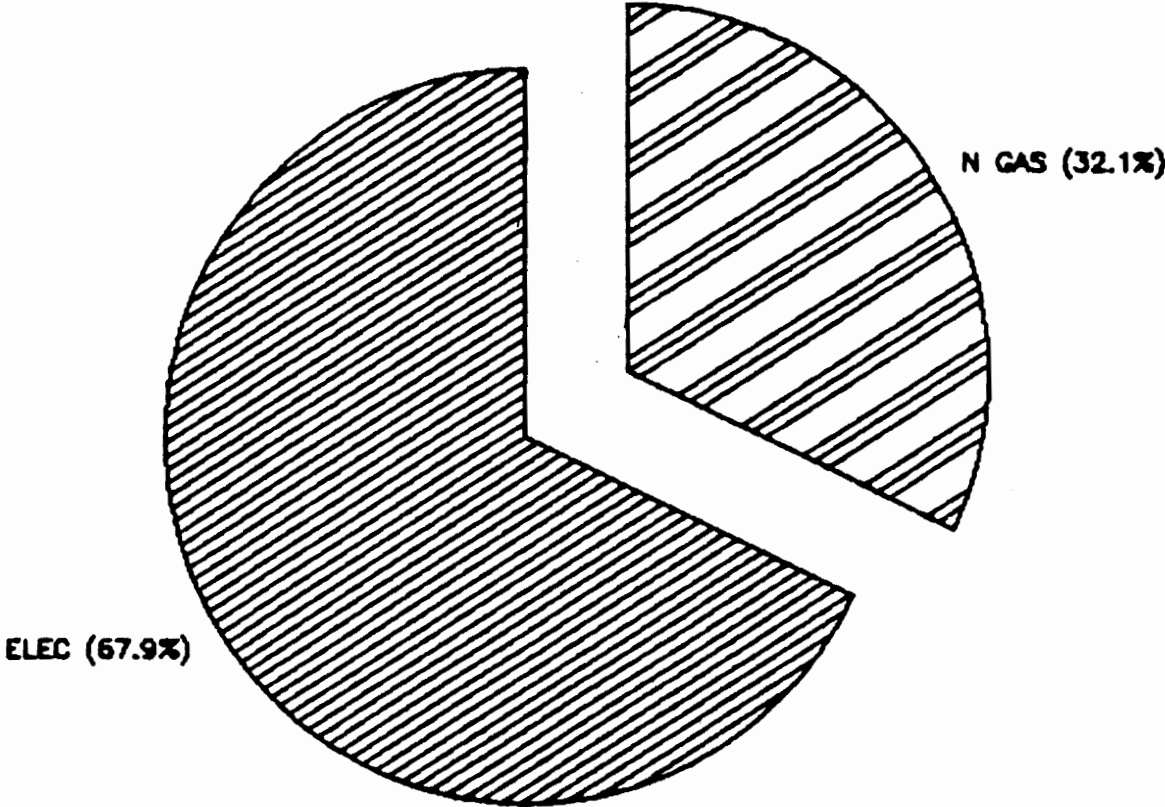


Figure 21. Example Pie Graph, Expenditures

REHABILITATION CENTER FOR THE BLIND
ENERGY USAGE BY BTUS CONSUMED: FY 1986

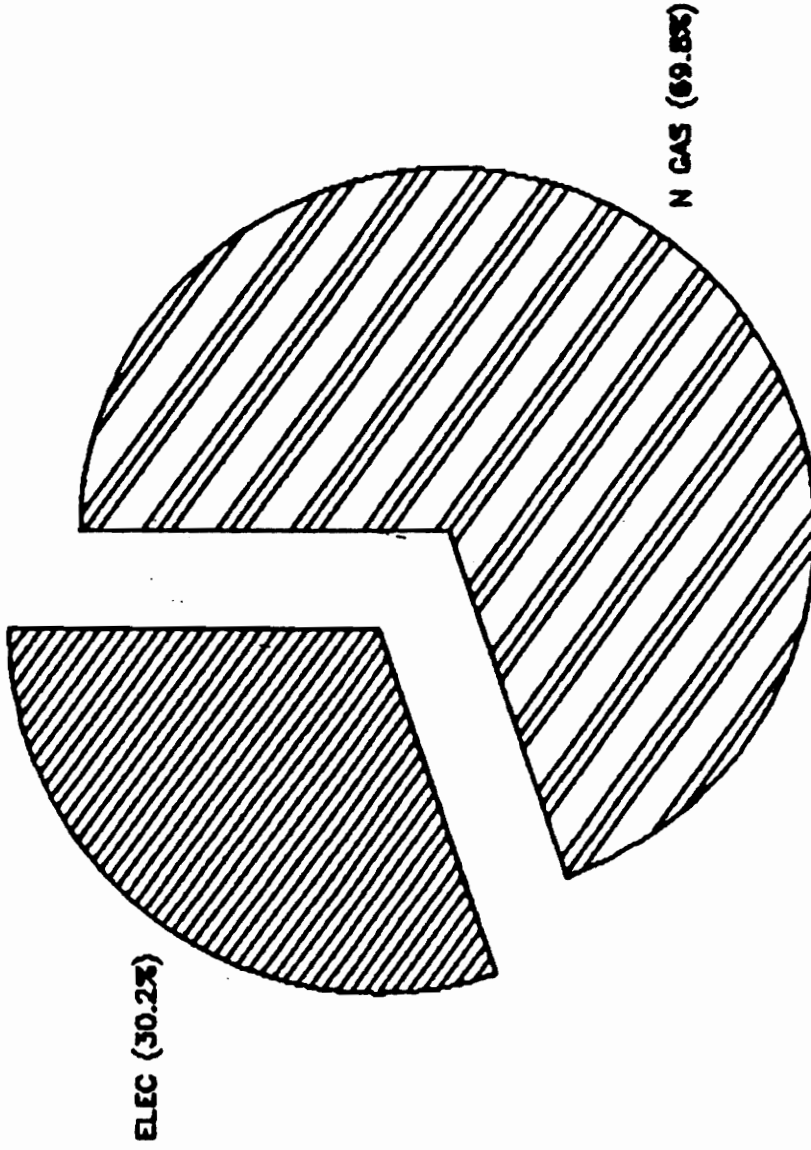


Figure 22. Example Pie Graph, BTUs

REHABILITATION CENTER FOR THE BLIND

ELECTRICITY

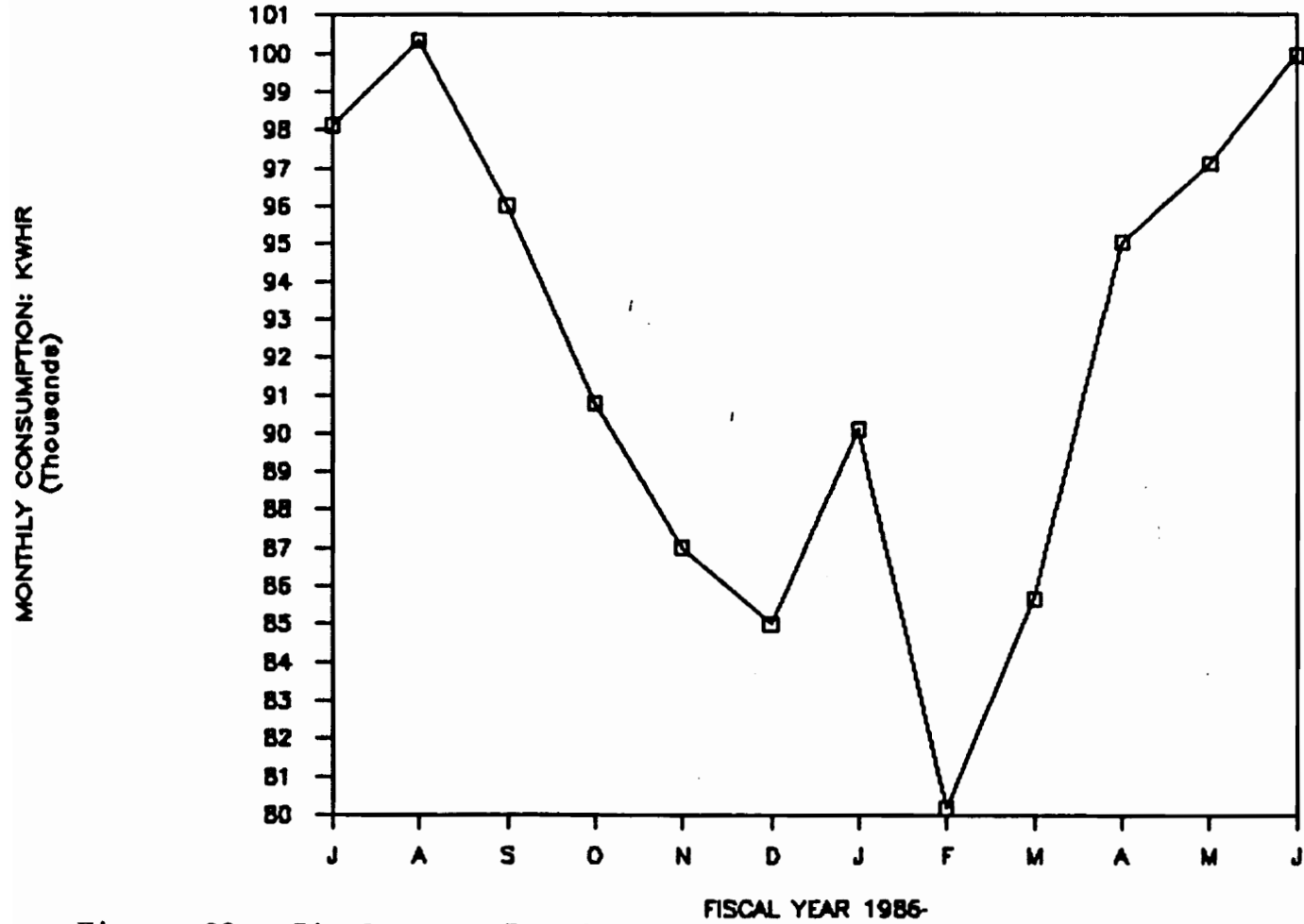


Figure 23. Single Year Particular Fuel Graph

REHABILITATION CENTER FOR THE BLIND

FACILITY TOTALS -- ALL FUELS

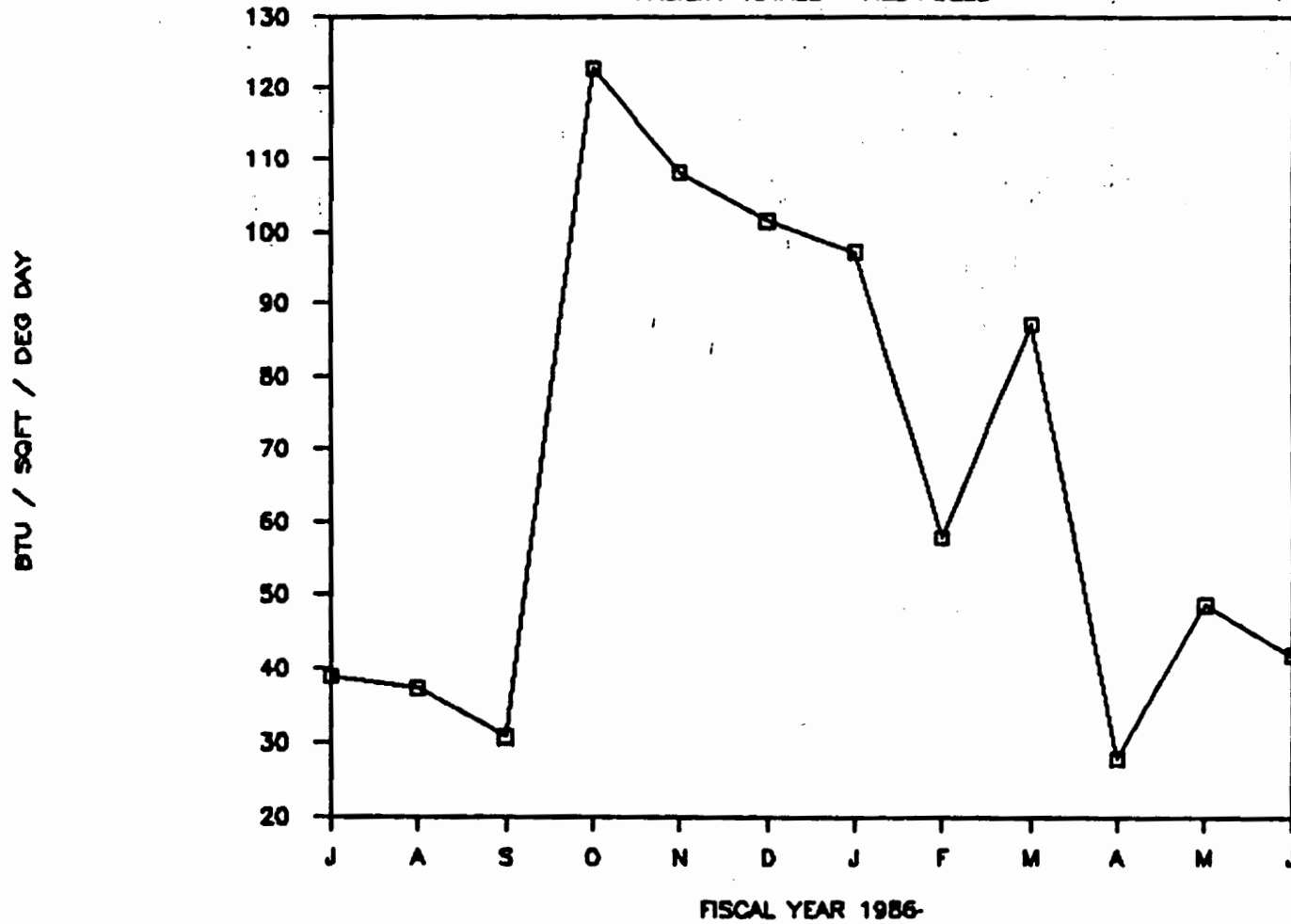


Figure 24. Single Year Facility Totals Graph

REHABILITATION CENTER FOR THE BLIND

ELECTRICITY

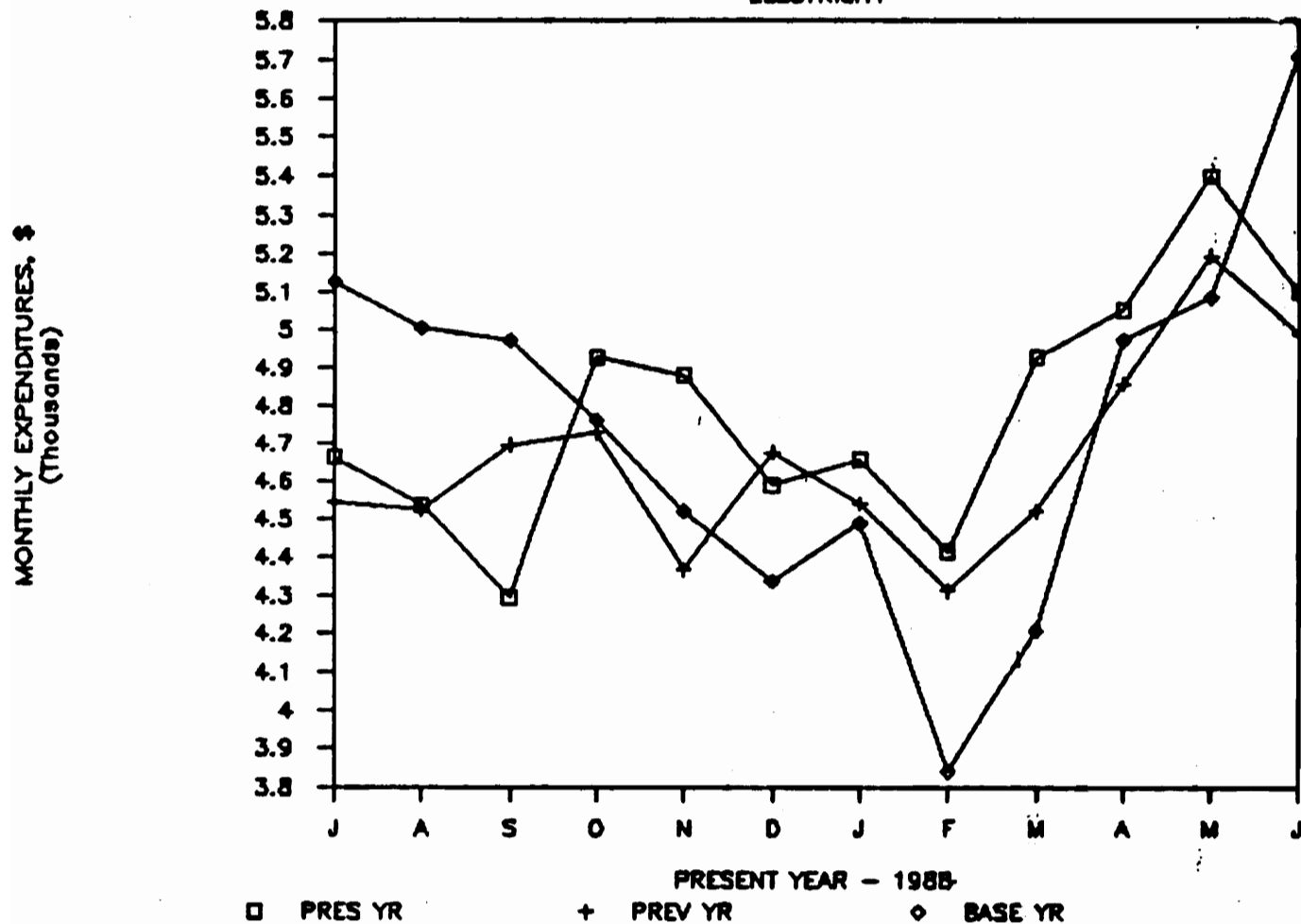


Figure 25. Particular Fuel Comparison Graph

REHABILITATION CENTER FOR THE BLIND

FACILITY TOTALS - ALL FUELS

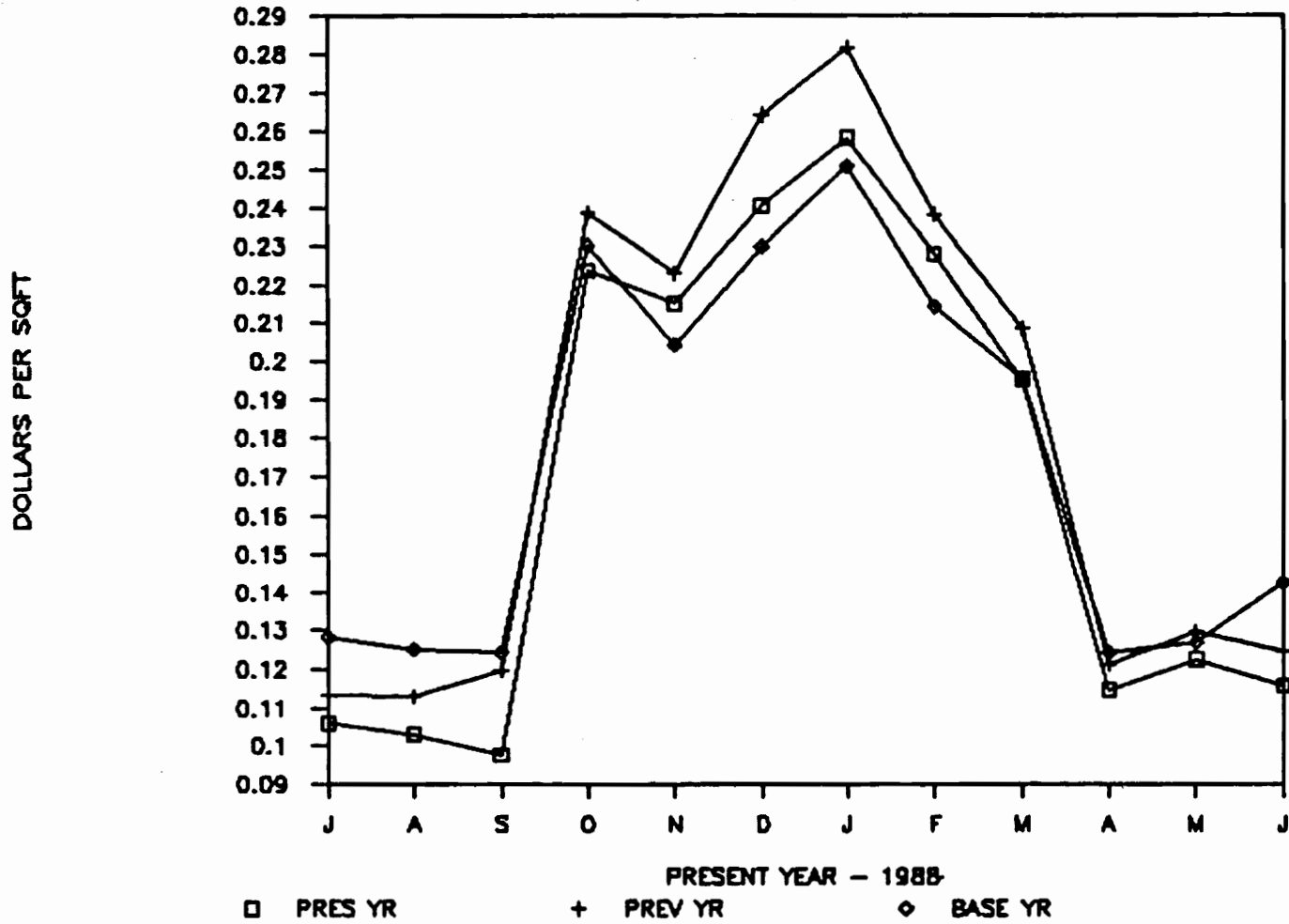


Figure 26. Facility Totals Comparison Graph

4.4.3 The RANK Menu Option

Choosing the RANK menu option from within the Master Menu Screen will enable the user to choose the menu options shown in Figure 27. Example outputs created using these menu options are presented in Figures 28, 29, and 30.

4.4.4 The DIV/FAC INFO Menu Option

Choosing the DIV/FAC INFO menu option from within the Master Menu Screen will enable the user to choose the menu options illustrated in Figure 31. Example outputs created using these menu options are presented in Figures 32 and 33.

4.5 Hardware and Software Requirements

The EMRS developed relies upon the availability of the following hardware and software:

- an authorized copy of Lotus Symphony version 1.2
- an IBM PC-AT compatible personal computer and monitor with a minimum of 512 K RAM, one (1) 1.2 mb diskette drive and one (1) 20 mb or greater fixed disk
- DOS 3.10 or greater to enable use of the above type of diskette drive
- Sideways software installed within the Symphony sub-directory
- a Symphony compatible text printer, and graphics printer or plotter

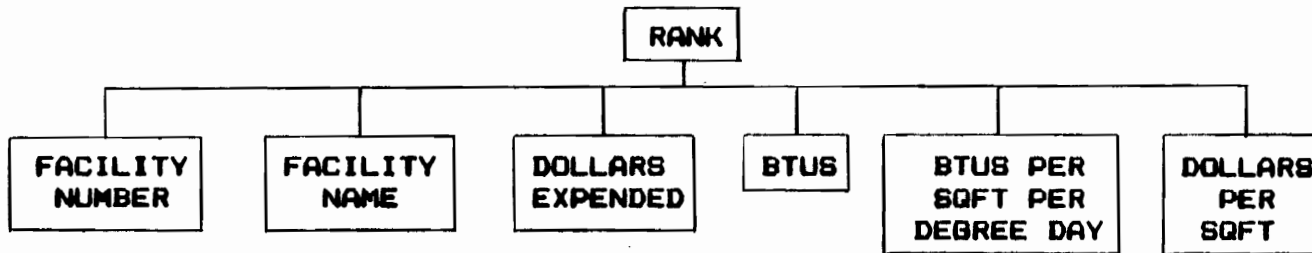


Figure 27. Ranking Menu Options

**RANKING OF FACILITIES
BY EXPENDITURES FOR ENERGY**

FISCAL YEAR 1986

FACILITY NUMBER	FACILITY NAME	EXPENDITURES FOR ENERGY	MILLIONS OF BTUS CONSUMED	FACILITY SQUARE FOOTAGE	ANNUAL DEGREE DAYS FOR FACILITY	BTUS PER SQUARE FOOT PER DEGREE DAY	ENERGY COSTS PER SQUARE FOOT
263	REHABILITATION CENTER FOR THE BLIND	\$83,851.11	12,445.667	40,000	4,267	72.92	\$2.10
702002	INDUSTRY F/T BLIND - RICHMOND	\$113,156.53	24,965.065	135,000	4,267	43.34	\$0.84
702001	VISUALLY HANDICAPPED, HQTRS-DEPT OF	\$125,871.47	16,609.088	75,000	4,267	51.90	\$1.68
702003	INDUSTRY F/T BLIND-CHARLOTTESVILLE	\$269,760.96	21,989.116	100,000	4,267	51.53	\$2.70
	TOTALS	\$592,640.07	76,008.936	350,000	4,267	50.89	\$1.69

Note: TOTALS figure for Annual Degree Days is an average for facilities shown. TOTALS figure for BTU/SQFT/DD is meaningless, unless ALL facilities submitted energy usage data.

Figure 28. Example Ranking of Facilities, By Expenditures

**RANKING OF FACILITIES
BY BTU PER SQUARE FOOT PER DEGREE DAY**

FISCAL YEAR 1986

FACILITY NUMBER	FACILITY NAME	EXPENDITURES FOR ENERGY	MILLIONS OF BTUS CONSUMED	FACILITY SQUARE FOOTAGE	ANNUAL DEGREE DAYS FOR FACILITY	BTUS PER SQUARE FOOT PER DEGREE DAY	ENERGY COSTS PER SQUARE FOOT
702002	INDUSTRY F/T BLIND - RICHMOND	\$113,156.53	24,965.065	135,000	4,267	43.34	\$0.84
702003	INDUSTRY F/T BLIND-CHARLOTTESVILLE	\$269,760.96	21,989.116	100,000	4,267	51.53	\$2.70
702001	VISUALLY HANDICAPPED, HQTRS-DEPT OF	\$125,871.47	16,609.088	75,000	4,267	51.90	\$1.68
263	REHABILITATION CENTER FOR THE BLIND	\$83,851.11	12,445.667	40,000	4,267	72.92	\$2.10
	TOTALS	\$592,640.07	76,008.936	350,000	4,267	50.89	\$1.69

Note: TOTALS figure for Annual Degree Days is an average for facilities shown. TOTALS figure for BTU/SQFT/DD is meaningless, unless ALL facilities submitted energy usage data.

Figure 29. Example Ranking of Facilities, By BTU Consumption Per Square Foot Per Degree Day

**RANKING OF FACILITIES
BY ENERGY COSTS PER SQUARE FOOT**

FISCAL YEAR 1986

FACILITY NUMBER	FACILITY NAME	EXPENDITURES FOR ENERGY	MILLIONS OF BTUS CONSUMED	FACILITY SQUARE FOOTAGE	ANNUAL DEGREE DAYS FOR FACILITY	BTUS PER SQUARE FOOT PER DEGREE DAY	ENERGY COSTS PER SQUARE FOOT
702002	INDUSTRY F/T BLIND - RICHMOND	\$113,156.53	24,965.065	135,000	4,267	43.34	\$0.84
702001	VISUALLY HANDICAPPED, HQTBS-DEPT OF	\$125,871.47	16,609.088	75,000	4,267	51.90	\$1.68
263	REHABILITATION CENTER FOR THE BLIND	\$83,851.11	12,445.667	40,000	4,267	72.92	\$2.10
702003	INDUSTRY F/T BLIND-CHARLOTTESVILLE	\$269,760.96	21,989.116	100,000	4,267	51.53	\$2.70
	TOTALS	\$592,640.07	76,008.936	350,000	4,267	50.89	\$1.69

Note: TOTALS figure for Annual Degree Days is an average for facilities shown. TOTALS figure for BTU/SQFT/DD is meaningless, unless ALL facilities submitted energy usage data.

Figure 30. Example Ranking of Facilities, By Expenditures Per Square Foot

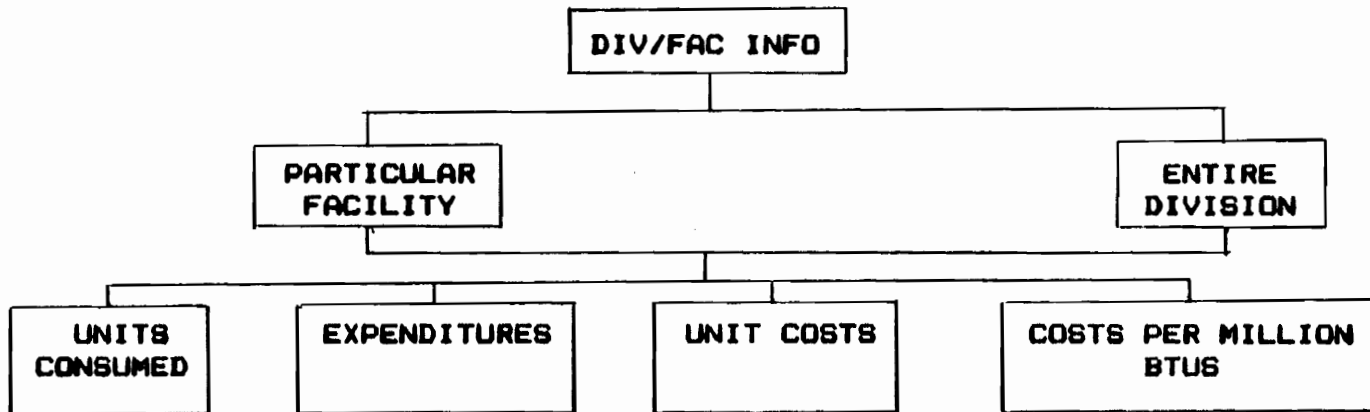


Figure 31. DIV/FAC INFO Menu Options

REHABILITATION CENTER FOR THE BLIND

FUEL TYPE & UNITS	UNIT CONSUMPTION						
	FISCAL YEAR (85-86)						
	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY
#1 OIL - gal							
#2 OIL - gal							
#4 OIL - gal							
#5 OIL - gal							
#6 OIL - gal							
NAT GAS - mcf				1,423.0	1,234.0	1,509.0	1,608.0
LP GAS - gal							
PUR STM - 1000 #							
ELECTRICITY - kwh	98,123.0	100,341.0	96,012.0	90,784.0	87,016.0	84,998.0	90,123.0
COAL - ton							
WOOD - ton							

Figure 32. DIV/FAC INFO Particular Facility Printout

REHABILITATION CENTER FOR THE BLIND

FUEL TYPE & UNITS	UNIT CONSUMPTION					FISCAL YEAR (85-86)
	FEBRUARY	MARCH	APRIL	MAY	JUNE	ANNUAL
	TOTAL/AVERAGE					
#1 OIL - gal						0.0
#2 OIL - gal						0.0
#4 OIL - gal						0.0
#5 OIL - gal						0.0
#6 OIL - gal						0.0
NAT GAS - mcf	1,520.0	1,209.0				8,503.0
LP GAS - gal						0.0
PUR STM - 1000 #						0.0
ELECTRICITY - kwh	80,189.0	85,678.0	95,017.0	97,123.0	99,960.0	1,105,364.0
COAL - ton						0.0
WOOD - ton						0.0

Figure 32 -Continued. DIV/FAC INFO Particular Facility Printout

DEPARTMENT OF VISUALLY HANDICAPPED

ENERGY EXPENDITURES

FISCAL YEAR (85-86)

	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY
FUEL TYPE & UNITS							
#1 OIL - gal							
#2 OIL - gal				\$2,892.98	\$642.62	\$7,176.70	\$8,891.48
#4 OIL - gal							
#5 OIL - gal							
#6 OIL - gal							
NAT GAS - mcf				\$4,445.37	\$3,650.91	\$4,858.98	\$5,547.60
LP GAS - gal							
PUR STM - 1000 #							
ELECTRICITY - kwh	\$47,024.59	\$45,460.52	\$44,734.79	\$44,636.10	\$41,679.05	\$40,205.45	\$38,473.32
COAL - ton				\$2,937.06	\$4,472.35	\$4,699.60	\$6,233.55
WOOD - ton							
TOTALS	\$47,024.59	\$45,460.52	\$44,734.79	\$54,911.51	\$50,444.93	\$56,940.74	\$59,145.95

Figure 33. DIV/FAC INFO Divisonal Printout

DEPARTMENT OF VISUALLY HANDICAPPED

ENERGY EXPENDITURES FISCAL YEAR (85-86)

FUEL TYPE & UNITS	FEBRUARY	MARCH	APRIL	MAY	JUNE	ANNUAL
						TOTAL/AVERAGE
#1 OIL - gal						\$0.00
#2 OIL - gal	\$7,546.41	\$3,858.25	\$568.15			\$31,576.59
#4 OIL - gal						\$0.00
#5 OIL - gal						\$0.00
#6 OIL - gal						\$0.00
NAT GAS - mcf	\$4,725.68	\$3,602.82				\$26,831.37
LP GAS - gal						\$0.00
PUR STM - 1000 #						\$0.00
ELECTRICITY - kuh	\$37,689.06	\$38,526.58	\$40,243.71	\$42,985.75	\$46,268.41	\$507,927.33
COAL - ton	\$4,799.60	\$3,162.61				\$26,304.77
WOOD - ton						\$0.00
TOTALS	\$54,760.75	\$49,150.26	\$40,811.86	\$42,985.75	\$46,268.41	\$592,640.07

Figure 33 -Continued. DIV/FAC INFO Divisional Printout

4.6 System Analysis

As stated in Section 1.3, the primary objective of this research was to develop an effective energy monitoring and reporting system for use by the State Energy Conservation Team. This system was developed to provide the necessary energy consumption information, regarding the State of Virginia's major energy consumers, to assist in the task of reducing energy usage. In developing a system to provide this information, expandability, maintainability, and reliability were of primary concern. In addition, system user-friendliness and ease of use were of paramount importance in development of a usable system. In reviewing the research completed, it is believed that the above goals were accomplished. Additionally, the EMRS developed is superior with respect to the previously utilized energy expenditure tracking system (CARS) in providing the types of information needed to manage the State's energy resources and funds.

System expandability was achieved in several ways. First, the system was developed in a manner that allows the addition of new facilities to each Division Diskette. Since the upper limit on the number of facility data files that can exist on a Division Diskette is approximately

forty (40), several divisions created could actually double their number of facilities being monitored. One exception to this, however, is the Community College division which contains thirty-three (33) facilities at present. In addition, new divisions can be created to allow for a broader based statewide EMRS. Finally, it is possible to overcome the ten-year limit that exists within the various data files. To do this, however, will require computer hardware upgrades for system dynamic RAM and investigation into the inability of the current Energy Team's computer fixed disk to work effectively with storage and retrieval of large data sets. This disadvantage was the central reason for developing a diskette-based system. Following rectification of the fixed disk hardware errors, upgrading of the computer's RAM will allow for storage of an additional ten (10) years worth of data for each 50 K of RAM added to the system. This is based upon the memory requirements of Symphony and of the largest data file, the SQFT file.

System maintainability was provided by use of effective programming techniques. These techniques involve permitting insertion of additional macro routines

to enhance system capabilities by providing additional space within each program and data file window. In addition, the description of the program's macros, as detailed within this work will enable those persons experienced in programming with Lotus products to edit or add program routines as desired.

System reliability was insured on two levels. First, the accuracy of the program routines in producing the desired outputs was insured through repeated testing utilizing sample data. Each program and data file was scrutinized over a six-month period to insure that accurate information would be output from the system as requested. Second, methods for validating input data, as described in Section 3.6 were developed.

In reviewing the example outputs and available output options in previous sections, it can be safely stated that the system developed indeed provides the State of Virginia with a necessary tool to develop an effective energy conservation program. As outlined in Chapter I, this system is but one of the many tools needed to manage energy resources, however, many of the remaining tools rely heavily upon a usable EMRS. As the discussion presented has unfolded, it becomes clear that previously existing

methods to track and report on energy usage, specifically CARS sub-program 482, were inadequate to meet the needs of the State Energy Conservation Team. The system developed, however, forms a solid base upon which the many facets of a statewide energy conservation program can rely upon.

CHAPTER V

RECOMMENDATIONS AND CONCLUSIONS

5.1 Recommendations

Recommendations on use of the Lotus Symphony based EMRS are as follows:

- a. Generation and distribution of quarterly reports on energy usage at each state facility. Each facility would receive reports detailing its particular energy usage, including: printouts of monthly usage as depicted in Figure 16, printouts of comparison energy usage (units, expenditures, BTUs, dollars per square foot per degree day), as illustrated in Figure 18, and graphs depicting each of these printouts including individual fuel and facility totals graphs. These quarterly reports would be submitted to the facility manager and designated energy coordinator.
- b. Distribution of quarterly reports on energy usage to heads of departments and branch secretaries. These reports would involve outlining the energy usage of a group of facilities, including: reports utilizing the ranking feature of the EMRS (using a variety of ranking criteria), month-by-month printouts of expenditures and units consumed, by fuel utilizing the AVGCST program, and comparison graphs for each facility within the division outlining the changes in energy usage with regard to expenditures, and BTU consumption per square foot per degree day. These final graphs would be based upon facility totals only to provide for a manageable report.

Distribution of these above reports would assist the energy management program of the state by promoting energy awareness; involving facility, department, and

branch heads with the state energy program; and providing valuable energy usage information for use by the Energy Team.

One area of further research available is the addition of program routines to permit indexing of expenditures based upon unit costs by fuel. This would allow for generation of expenditure and expenditure per square foot printouts and graphs on an adjusted basis to illustrate the effect of fuel unit costs on facility and division energy expenditures. Choice of an index based upon unit costs for the first year of the energy management program (FY 1985-86) would provide for this additional feature. Creation of indexed printouts and graphs is currently possible, but requires manual manipulation of data within Lotus Symphony and requires programming experience.

A second area of further research that would have the most pronounced effect upon use of the EMRS developed would be the transfer of Division Diskettes to individual fixed disk drive sub-directories. As previously stated, shortfalls in existing computer hardware has prevented this option from consideration. However, the added benefits of

increased program speed and the ability to store more than ten years of data in each data file may warrant the overhaul or replacement of existing fixed disk drives.

A third area of further research involves developing a method to adjust the y-axis on graphs to include the zero baseline. This is desired to prevent erroneous analysis of data that may occur when graphs are created using suppressed y-axis values (e.g. a y-axis of 120,000 to 150,000 instead of 0 to 150,000). The suppressed y-axis illustrated in the various example graphs are created automatically by Symphony. This method was chosen to assist with system user-friendliness. It may be desirable, however, to incorporate a method where the user manually sets y-axis values based upon the graph automatically generated, if indeed this is possible.

One final area of further research would be to differentiate energy usage calculated on a BTU per square foot per degree day basis by the type of degree day (heating or cooling). This could possibly lead to creation of two separate energy index values, a BTU/SQFT/HDD for heating months, and a BTU/SQFT/CDD for cooling months. This area of research is mentioned because of the variances

in energy input requirements in meeting a heating or cooling load. Therefore, facilities within a division with sizeable differences in heating and cooling requirements (i.e. heating and cooling degree days), may be ranked inappropriately due to these differences, since the present energy index uses total number of degree days instead of breaking down energy usage between heating and cooling. Further analysis of this phenomenon, and how it may be effectively modeled, would be required before being incorporated into the EMRS, however, this is beyond the scope of this thesis.

5.2 Conclusions

This research has focused upon creation of an energy monitoring and reporting system (EMRS) for Virginia state-owned and operated facilities. More specifically, the research outlines a Lotus Symphony based program which forms the basis of this EMRS. Development of this system was necessitated due to the unavailability of detailed energy consumption information from existing state accounting systems. This EMRS provides an essential element of a comprehensive statewide energy management program by providing this necessary information.

The research objective was to provide various energy related data concerning individual facilities, as well as groups of facilities, as outlined in Section 1.3. A review of the available data input and output options, as presented in the previous chapter, clearly indicates that the research objective was successfully achieved. The extensive reporting capabilities of the EMRS developed, in both tabular and graphical form, enable the user to quickly assess the level of energy consumption at a chosen facility or for a group of facilities, compare energy usage at similar individual facilities, and review the progression of each facility's energy management program. The menu-driven structure of the program further allows even the inexperienced computer user to enter data and produce these valuable energy usage reports upon demand.

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APPENDIX A

FACILITIES CHOSEN FOR VIRGINIA EMRS

FACILITY/AGENCY NUMBER	FACILITY NAME
UNIVERSITIES AND FOUR YEAR COLLEGES AND CERTAIN CAMPUS BRANCHES	
204	College of William and Mary
206	Va Commonwealth University, Medical Campus
207	Univ. of Virginia, Academic Campus
208	Virginia Tech, Main Campus
209	Univ. of Virginia, Hospital Division
211	Virginia Military Institute
212	VA State University
213	Norfolk State University
214	Longwood College, Main Campus
215	Mary Washington College
216	James Madison University
217	Radford University
221	Old Dominion University
236	VA Commonwealth University, Academic Campus
241	Richard Bland College
242	Christopher Newport College
246	Clinch Valley College
247	George Mason University, Main Campus
268	VA Institute of Marine Science

VIRGINIA COMMUNITY COLLEGE SYSTEM

275	New River Community College
276-001	Southside Community College- Christanna Campus
276-002	Southside Community College-John H. Daniels Campus
277	Paul D. Camp Community College
278-001	Rappahannock Community College-North Campus
278-002	Rappahannock Community College-South Campus
279	Danville Community College
280-001	N. VA Community College-Alexandria Campus
280-002	N. VA Community College-Annandale Campus
280-003	N. VA Community College-Loudoun Campus

FACILITY/AGENCY NUMBER	FACILITY NAME
280-004	N. VA Community College-Manassas Campus
280-005	N. VA Community College-Woodbridge Campus
282	Piedmont VA Community College
283-001	J. Sargent Community College-Parham Road Campus
283-002	J. Sargent Community College- Downtown Campus
283-003	J. Sargent Community College-Western Campus
284	Eastern Shore Community College
285	Patrick Henry Community College
286	VA Western Community College
287	Dabney S. Lancaster Community College
288	Wytheville Community College
290	John Tyler Community College
291	Blue Ridge Community College
292	Central VA Community College
293	Thomas Nelson Community College
294	Southwest VA Community College
295-001	Tidewater Community College- Frederick Campus
295-002	Tidewater Community College-VA Beach Campus
295-003	Tidewater Community College- Chesapeake Campus
296	VA Highlands Community College
297	Germanna Community College
298	Lord Fairfax Community College
299	Mountain Empire Community College

DEPARTMENT OF CORRECTIONS

709	Powhatan Correctional Center
710	Virginia State Penitentiary
711	Bureau of Industrial Enterprises
712	Bon Air Learning Center
713	Beaumont Learning Center
714	Barrett Learning Center
715	Hanover Learning Center
716	VA Correctional Center for Women at Goochland

FACILITY/AGENCY NUMBER	FACILITY NAME
717,736,740	Southampton Correctional Complex
718	Bland Correctional Center
719	James River Correctional Center
730	Brunswick Correctional Center
731	Staunton Correctional Center
732	Natural Bridge Learning Center
733	Reception and Diagnostic Center for Children
737	St. Brides Correctional Center
741	Appalachian Learning Center
743	Oak Ridge Learning Center
744	Mecklenburg Correctional Center
745	Nottoway Correctional Center
747	Marion Correctional Center
749	Buckingham Correctional Center
753	Deerfield Correctional Center
754	Augusta Correctional Center

DEPARTMENT OF MENTAL HEALTH AND MENTAL RETARDATION

704	Eastern State Hospital
705	Southwestern State Hospital
706	Western State Hospital
707	Central VA Training Center
708	Dejarnette Center
723	Southeastern VA Training Center
724	Catawba Hospital
725	Northern VA Training Center
727	VA Treatment Center for Children
728	Northern VA Mental Health Institute
729	Piedmont Geriatric Center
738	Southwestern VA Training Center
739	Southern VA Mental Health Institute
703,726,746 748	Southside Mental Health and Mental Retardation Complex at Petersburg

DEPARTMENT OF THE VISUALLY HANDICAPPED

263	Rehabilitation Center for the Blind
702-001	Dept. of the Visually Handicapped Headquarters
702-002	VA Industry for the Blind-Richmond
702-003	VA Industry for the Blind- Charlottesville

FACILITY/AGENCY
NUMBER

FACILITY NAME

DEPARTMENT OF EDUCATION

218	VA School for the Deaf and Blind At Staunton
219	VA School for the Deaf and Blind At Hampton

DEPARTMENT OF REHABILITATIVE SERVICES

203	Woodrow Wilson Rehabilitation Center
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MUSEUMS

146	Science Museum of Virginia
238	VA Museum of Fine Arts

DEPARTMENT OF GENERAL SERVICES

194	Department of General Services
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APPENDIX B

USER'S GUIDE

I. How to Start the EMRS

Access the Symphony program and enter a new worksheet, then:

1. Insert the desired Division Diskette in Drive A.
2. Press F9 (the Service Key in Symphony).
3. Press F (for File) and R (for Retrieve). Then press the Esc (Escape) key TWICE.
4. Type (in caps or small letters) A:\START and press the Enter key.
5. Wait for the EMRS logo to appear, then follow on-screen directions.

II. What To Do If You Receive An ERROR Message

The EMRS developed is a menu-driven interactive program which allows the user to input a minimum of keystrokes and receive a maximum of energy usage information. Certain safeguards have been taken to insure that what the user types (in the form of facility numbers and fiscal years) is correct before the program attempts to retrieve data files and compute, print and/or graph energy usage patterns. However, it is possible for the user to inadvertently press a wrong key, or to answer yes to a computer generated question when the correct answer was no.

Several things could cause the program to stop, beep, and flash a red ERROR message in the upper right-hand corner of the screen. If this ERROR message does occur, take these simple steps:

1. Press the ENTER key. This will stop the ERROR message from flashing.
2. Restart the EMRS program using the steps outlined in Part I.

III. How To Generate Graphs Using the EMRS and the Symphony PrintGraph Program

If you choose to create a graph within the EMRS, you will be prompted to enter the necessary information to retrieve data and create a graph. Information such as type of graph desired, facility number, present year, fuel type, etc. is to be entered by the user. The EMRS will then retrieve data and produce a graph on the monitor. After viewing this graph the user is asked if he wishes to create a .PIC file for the purpose of creating a hardcopy of this graph image using the Symphony PrintGraph program.

If you enter Y (yes) to this question, you will then be prompted to enter the name to be used for storing the graph image (in a .PIC file). Certain restrictions and suggestions on entering this .PIC filename are presented. It should be kept in mind that to produce a hardcopy of a graph image it will be necessary to exit

the EMRS, exit Symphony, and enter the PrintGraph program. Once the .PIC file has been created, you will be returned to an interactive menu and you can choose to create additional graphs, continue in the program or to exit the EMRS.

When creating .PIC files to store graph images, it will be necessary to produce a hardcopy of these images before the computer is turned off. When the computer is restarted (either by switching on the Master power switch or by pressing Ctrl-Alt-Del) the Autoexec.Bat file on the fixed disk root directory erases all .PIC files contained on the EMRS sub-directory. This was done to prevent an excessive number of .PIC files from being stored on the EMRS fixed disk sub-directory. Also, the EMRS program operates in such a manner that no two .PIC files can have the same name for obvious reasons (the second .PIC file would erase the first graph image using the same .PIC filename). To produce a graph image for a .PIC file created follow these steps:

1. Exit the EMRS using the EXIT menu choice. You will first have to exit the graphing program then exit the EMRS from the Master Menu Screen. When you have exited from the EMRS a new Symphony SHEET window will appear on the screen.
2. Press F9 (the Services key in Symphony).

3. Press E (for Exit) to Exit from Symphony and to enter the Symphony Access System menu.
4. Press Y (Yes) to confirm that you wish to exit Symphony.
5. The Symphony Access System menu will appear on the screen. Press P to choose the PrintGraph program to create a hardcopy of graph images.
6. When the Printgraph Settings Sheet appears, Press S (Settings.)
7. Press H (Hardware).
8. Press G (Graphs-Directory).
9. Press the Esc (Escape) key once.
10. Type in small or caps the pathname of the EMRS fixed disk sub-directory.
11. Press Q (Quit).
12. Press Q (Quit) again.
13. Press I (Image-Select).
14. Use on-screen instructions to select files to be graphed by the printer or plotter. Again, the filenames that appear are those created during the EMRS session, and all have the .PIC extension (not shown). Once the # sign appears beside all files desired press the Return key to return to the PrintGraph Menu.
15. Turn the Printer on and insure that paper is aligned to the top of a page.
16. Press A (Align).
17. Press G (Go).

Each graph chosen will take approximately two (2) minutes to print. While the printer is creating hardcopies of your graphs, do not press keys on the keyboard or the printer.

When printing is complete and the PrintGraph Menu appears, press E (Exit) to return to the Symphony Access System menu. Then you may return to Symphony, the EMRS, or return to the Disk Operating System (DOS).

IV. Working With The Weather.Wrl File

As previously stated, the Weather.Wrl File is a common file on each Division Diskette. In other words, this file should be precisely the same on each and every Division Diskette. This occurs because the Weather.Wrl file contains certain degree day data for each of the six weather regions defined in the EMRS (see Figure 6 for a map of these regions).

Therefore, when working with the Weather.Wrl file it is necessary to follow the pattern below:

1. Make changes or additions in degree days for the region(s) desired on a Division Diskette. To avoid confusion it may be desirable to make changes to the Weather.Wrl file at certain times, say at the first of each month using a certain Division Diskette to make initial changes or additions, then transferring these changes to the remaining Division Diskettes.

2. Return to the Master Menu Screen from the Weather.Wrl file by pressing ALT-S. This will save the updated degree day information on the Division Diskette presently contained in Drive A.
3. When the Master Menu Screen appears, choose a.) Input Data then b.) Weather Data using the menu choices given.
4. When the Weather.Wrl file is retrieved, remove the current Division Diskette from Drive A and set it aside. Be sure you know which Division Diskettes have the updated Weather.Wrl file.
5. Insert a new Division Diskette into Drive A which does not contain the updated Weather.Wrl file.
6. Repeat steps 2 through 5 until all Division Diskettes contain the updated Weather.Wrl file.

To insure that each Division Diskette has the updated Weather.Wrl file, it will be necessary to exit the EMRS, exit Symphony, and enter DOS. Insert each Division Diskette, one at a time, into Drive A. Change the default drive by typing (small or caps): A:

and the pressing Return.

Type (small or caps):

DIR/P

and then press Return.

Look for information concerning the Weather.Wrl file. Note the date and time created, and the bytes required to store this file. Remove the first Division Diskette from Drive A and insert a second. Again type:

DIR/P

and then press Return.

Again, note the date and time the Weather.Wrl file was created and the bytes of diskette space required to store the file.

Continue to change Division Diskettes and obtain the pertinent information regarding the Weather.Wrl file for each diskette. The date created on each diskette should be the same. The time created for the Weather.Wrl files should be close to one another. A Weather.Wrl file with a creation time vastly different from the other Weather.Wrl files should be suspect. Finally, the bytes of storage space for each Weather.Wrl file should be the same.

If any Weather.Wrl file is suspect on any of these conditions, insert a Division Diskette you feel contains a correct Weather.Wrl file into Drive A and enter the EMRS. Bring up the Weather.Wrl file from this "good" diskette. Remove the "good" diskette, and insert the diskette containing the suspect Weather.Wrl file. Save the Weather.Wrl file onto this second diskette by pressing ALT-S. Repeat the steps outlined in the above paragraph for each Division Diskette containing a suspect Weather.Wrl file.

V. Making Division Diskette Backups

A backup diskette of each Division Diskette has been made and is labeled:

DIVISION NAME BACKUP DISKETTE -- Date

This backup, contains the program files and, initially, empty data files. These data files will remain empty until data is input and the Division Diskettes are backed up.

It will be necessary to make backups of Division Diskettes each time data files of any type (facility, weather, or square footage) are used.

Thus, each time a data file (facility, weather, or square footage file) is used, and immediately after exiting the EMRS and returning to a blank Symphony Sheet window, with the Division Diskette still in Drive A:

1. Attach the DOS add-in application by:
 - a. Pressing F9 (Services key in Symphony)
 - b. Press A (Application)
 - c. Press A (Attach)
 - d. Choose DOS by moving the cursor over DOS.APP and pressing return or by typing DOS and pressing return.

Note: If the DOS application is already attached, the computer will beep and flash a red ERROR message in the upper right-hand corner. If this occurs simply press return, press F9, press A (Application) and proceed to step e.

- e. Press I (Invoke)
- f. Choose to invoke the DOS add-in by moving the cursor over DOS and pressing return or by typing DOS and pressing return.
- g. Press return when prompted to:

Press [RETURN] or enter program name:

- 2. When the Symphony sub-directory prompt appears change the DOS prompt to the EMRS sub-directory and press return.
- 3. Type BU, press return, and follow on screen instructions.
- 4. When prompted, replace the working Division Diskette in Drive A with the correct backup diskette for that particular division.
- 5. Press any key as instructed by on-screen instructions.
- 6. Remove the backup Division Diskette when backup process is completed.
- 7. Insert the working Division Diskette into Drive A.
- 8. Type EXIT and press return. This will return you to a new Symphony Sheet window. From here you may reenter the EMRS or continue with other programming tasks in Symphony.

For reasons previously mentioned, these backup procedures should ideally be performed each time you insert or change data within the data files.

VI. Adding Or Deleting A Facility From A Division Diskette

The first version of the EMRS completed in July of 1987 was developed for the one hundred largest energy

consuming facilities for the State of Virginia. Therefore, if it is desirable to add (or delete) facilities to any Division Diskette, or to create an entirely new Division Diskette, one must be aware of the locations, within the program files, of facility names and identifying numbers that the EMRS uses to retrieve data and establish printout titles and labels.

If a new facility is to be added to an existing Division Diskette, a new data file for that particular facility will need to be created. To do this, retrieve the DATAIN.Wr1 file on the Division Diskette that you wish to add a facility to, and as the file is being retrieved, at the same time press CTRL-BREAK. If you have done everything properly to this point, you will see a screen with PLEASE WAIT in the center and a flashing red ERROR message in the upper right-hand corner of the screen when the file is retrieved. If you do not see this on the screen, obtain a new worksheet and try again. When the screen appears in the correct manner, press Return to clear the ERROR message, enter the MAIN window, move the cursor to cell B2 and type in the new facility's number (agency or tract number and name). Return to the MESSAGE window, and save the file using the facility's agency or tract number as the filename.

In addition, this new facility (and facility number) will need to be added to the Sqft.Wr1 file. For the Sqft.Wr1 file it will also be necessary to add range names to identify the cell locations of square footages for each of the fiscal years given in the Sqft.Wr1 file.

Locations of facility names and numbers within program files are presented below. Should it become necessary to add a facility to a Division Diskette, add the appropriate information, as shown for the other facilities on the Division Diskette, in the same manner at the end of the list of facilities. Be sure to include the weather region number if it is shown for other facilities (some lists do not require the use of this region number). Once you have completed making changes to these program files, return to the PLEASE WAIT or the MESSAGE window (some files have a PLEASE WAIT window, others have a MESSAGE window) and save the file. After making changes to all program files, immediately backup the diskette. The cell locations given below are the top of the list of facility names and numbers and appropriate information.

To allow for inserting or deleting the facility information outlined below, when retrieving the file, press CTRL-BREAK to stop execution of the auto-execute macros in each file. Press return to clear the

ERROR message when it appears. If you do not receive an ERROR message, retrieve the file again, pressing CTRL-BREAK until you do.

<u>File</u>	<u>Window</u>	<u>Location of Information</u>
MSTMNUW.Wr1	FAC NAMES & NOS	O11 & R11 Update both lists, adding new facility name and number in correct order in each list
	MASTMENU MACROS	D21 Add information for new facility at end of the shown list. Be sure to include ALL information shown for other facilities
AVGCST.Wr1	MACROS	F1 Add new facility number where the word END now appears as a LABEL, that is, enter '194 for example, not 194. BE SURE TO HAVE the word END (ALL CAPS) AS THE LAST ENTRY

IF creating a new Division Diskette, enter the correct Division Name at the location of the range name "Division Name", located within the MACROS window at H10.

RANK1.Wr1	MACROS	L1 and N1 Add new facility number where the word
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<u>File</u>	<u>Window</u>	<u>Location of Information</u>
		END appears as a NUMBER. This is different from the way agency numbers are listed in AVGCST.Wr1. BE SURE TO HAVE the word END (ALL CAPS) AS THE LAST ENTRY IN THE LIST
PRINT1.Wr1	INPUT	AB16 Enter information for new facility at the end of the shown list, being sure to include ALL information shown for other facilities
PRINTC.Wr1	INPUT	J16 Follow same instructions as for PRINT1.Wr1
GRAPH1.Wr1	RETRIEVE	P134 Follow same instructions as for PRINT1.Wr1
GRAPHC.Wr1	RETRIEVE	P134 Follow same instructions as for PRINT1.Wr1

Should it become necessary to remove a facility from a Division Diskette, simply remove reference to that facility by erasing the facility number and/or information as outlined above, in each file. After you erase the

information, move the remainder of the list up using the Move command, so as not to leave a blank row. DO NOT LEAVE A BLANK ROW IN ANY OF THE LISTS PRESENTED ABOVE.

It also is necessary to erase reference to facilities being removed from a Division Diskette in the SQFT1 file. This can be accomplished by erasing the facility name and number shown in the left-most column and deleting all ranges referring to this facility.

VII. How To Restore System Files

A. Division Diskettes

Should something happen to one of the Division Diskettes, such that the diskette is unusable, it will be necessary to use the backup Division Diskette to restore the program and data files.

Exit the EMRS, Symphony, and return to the DOS prompt. Obtain a new, unformatted 1.2 Mb diskette, and format it following instructions found in the DOS manual.

Next, insert the backup Division Diskette into Drive A and:

1. Type the fixed disk drive DOS sub-directory pathname and press return
2. Type (small or caps) DISKCOPY A: B: and press return

3. The message:

Insert SOURCE diskette in drive A:
Press any key when ready . . .

will appear

The backup diskette is the SOURCE diskette so
press any key at this point

It is important to remember to never insert or
remove a diskette from the disk drive when the red
light above the drive is on. A permanent loss of
data may occur.

4. When prompted to insert the TARGET diskette,
remove the backup diskette, and insert the new,
formatted diskette in Drive A and press any
key.

5. Continue to change diskettes into and out of
Drive A as prompted. When the following
message appears:

Copy another diskette (Y/N)?

Press N and then press return.

6. To insure that the new Division Diskette is
exactly the same as the backup, insert the
backup diskette into Drive A and type:

DISKCOMP A: B:

7. Again, interchange the backup diskette and the
new working Division Diskette into and out of
Drive A as prompted.

8. If you do not eventually see the message:

Compare OK

obtain a new, formatted 1.2 Mb diskette and
return to step 1.

9. When the Compare OK message appears, you are assured that the new working diskette and the backup diskette are the same.
10. Return the backup diskette to a safe place and continue to use the new working Division Diskette to run the EMRS.

B. External Files

To restore external files, exit the EMRS, Symphony, and return to the DOS prompt. Obtain a copy of the EMRS external files master diskette and place it in Drive A. Next,

1. Enter the EMRS fixed drive sub-directory.
2. Type COPY A: *.* and press return. This will copy the OUT-1.SPS, OUT-2.SPS, BU.BAT, TEMP.Wr1, and XXX.XXX files to the EMRS sub-directory.

At this point, all external files have been restored, and the EMRS sub-directory external files should be as shown below. Return the external files master diskette to a safe place and continue in the EMRS.

<u>File Name</u>	<u>EXT</u>	<u>BYTES</u>	<u>Date/Time</u>
OUT-1	SPS	441	
OUT-2	SPS	441	" "
TEMP	WR1	501	" "
XXX	XXX	501	" "
BU	BAT	272	" "

VIII. Miscellaneous

When entering data into any of the data files, NEVER use the Symphony Move or Copy commands. Use of these commands may alter the position of certain range names, which are utilized to retrieve data from within program files, causing the program to malfunction.

VITA

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