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A MANAGEMENT INFORMATION SYSTEM FOR
THE ENERGY CONSERVATION PROGRAM

THESIS

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AFIT/GEM/LSM/90S-5

The opinions and conclusions in this paper are those of the author and are not intended to represent the official position of the DOD, USAF, or any other government agency.

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THESIS

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Abstract

This study investigated the possibility of creating an energy accounting system based on currently identified objectives. The initial focus was to determine if such a system would be useful. By reviewing literature, it became obvious that the conditions which lead to the energy crises in the 1970's still exist. In fact, most of the indicators are that the United States is more dependent upon foreign oil than at any time in the past. There was also a Couple this finding with the failure to meet the 1985 energy reduction goal of 20%, and it is obvious that something needs to be done.

Adding to the problem is escalating pressure to trim the federal budget. The greatest pressure is on the Department of Defense. Thus, there is a need to improve the methods used to determine how to decrease facility energy consumption. It was found

The findings were that any new systems needs to decrease the time required to prepare reports, allow the flexibility to customize reports, and provide a method for upward reporting of contract data. The result of this study showed that it was possible to create such a system, but given the tools currently available not all of the objectives were obtainable. Keywords: Management engineering; Oil consumption; Energy management/consumption; Military facilities; Theses. (NMJ)

A MANAGEMENT INFORMATION SYSTEM FOR
THE ENERGY CONSERVATION PROGRAM

I. Introduction

Overview

The purpose of the discussion presented in this chapter was to provide the justification, purpose and parameters for this research. To get a thorough understanding of the problem, it was necessary to assess the environment surrounding the research problem. This evaluation included looking at the energy conservation program, future energy consumption trends, and the duties and responsibilities of energy conservation personnel. Once this was done, the focus was narrowed to describe the precise research topic.

Background

The Air Force's interest in energy conservation started in the 1970's when the United States experienced several energy crises. These crises were precipitated by the Organization of Petroleum Exporting Countries' (OPEC) decision to limit oil production of its member nations. During that time over 60 percent of the world's oil production was controlled by OPEC (1:6). This highlighted the United States dependence on foreign oil and proved its market was vulnerable to oil shortages. The United States imported 35 percent of its oil (2:17).

One of the Federal Government's reactions to the decrease in the oil supply was Executive Order 12003, which made it mandatory for federal agencies to reduce energy consumption. The Air Force implemented this Order in the Energy Conservation (ECON) Program and published its Energy Plan as a guide for achieving the objectives of the Executive Order. The plan separated energy consumption into three different areas, aircraft fuels, vehicle fuels and facility energy, and tasked different organizations to manage each of them. This paper deals exclusively with facility energy and Civil Engineering (CE) personnel's responsibilities in managing the energy conservation program.

The Air Force's energy reduction target for the 10 years between Fiscal Year (FY) 76 and FY85 was 20 percent. This optimistic reduction goal was feasible with judicious changes to facilities. Unfortunately, the first actions taken to meet the goal were actually reactions. The Air Force wanted an immediate decrease in consumption. Thus, building space conditioning (air conditioning and heating) was targeted as the quickest way to achieve significant reductions. The possible side effects of this approach, such as the decrease in worker productivity, were ignored.

The next step was the upgrade of older facilities. If a facility was scheduled for renovation, energy efficient windows and doors were added to the project. When a mechanical or electrical system was replaced due to functional problems, the replacement had to meet minimum energy efficiency standards.

Facilities showing poor energy performance, but not scheduled for renovation, were upgraded with energy efficient doors and windows and additional ceiling insulation. These changes to programmed renovations and these additional small projects were relatively inexpensive and quickly paid for themselves with reduced energy cost.

In 1976 the Air Force initiated the Energy Conservation Investment Program (ECIP). This program was designed to provide additional funding for energy conservation projects which would pay back the initial investment within 10 years (3:60). The projects identified for this program were presented to congress as a separate funding request package.

Even with the special attention and high visibility of the energy program, the Air Force did not meet the 1975 goal; the reduction achieved in facilities energy consumption was only 18.6 percent (4:19).

In 1985, the Air Force revised its energy plan. This new plan mandated a further 10 percent reduction in facility energy use by 30 September 1995. This plan attacked the reduction from two directions. First, existing buildings (buildings with a beneficial occupancy date before 1 October 1985 - FY86) must have reduced energy consumption by an average of 10 percent from the amount they used in 1985.

Second, new buildings (buildings with a beneficial occupancy date after FY85) must have been designed to consume 10 percent less energy than a building used for the same activities constructed before FY86. The Air Force established energy budget figures (EBF) (maximum energy consumption quantities) for each building category code (designation of facilities by usage). The designer had to show that the proposed design of any new facility achieved this target value. Building energy consumption was metered and the first year's consumption reported to Headquarters Air Force.

To monitor the progress made towards both of these targets the EOON Officer constantly tracks the energy used by new and existing facilities and compares their present usage to the FY85 consumption quantities.

Compounding the technical problems, the Air Force Budget has not kept pace with inflation (Figure 1.). The Air Force Budget Authority has decreased from $115,444 million in FY 1985 to $97,622 million in

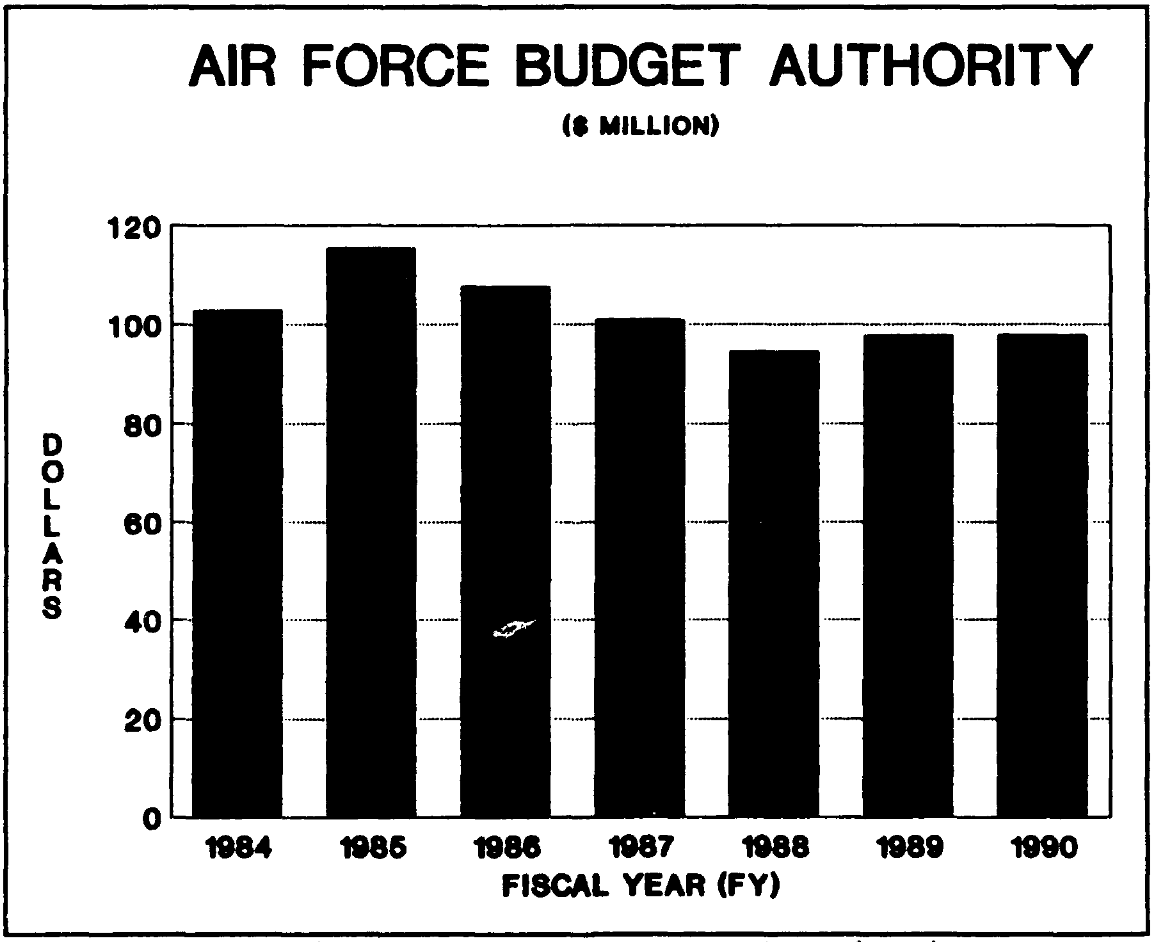

Figure 1. Past Air Force Budgets (5:67)

FY90 (5:67). This is a 15 percent reduction in spending power over the last five years. This trend is expected to continue:

> It was further told (by Defense Secretary Frank Carlucci) the services to (sic) assume a "five-year drought" in which their funding will be ten to twelve percent lower than projected by the old, now-defunct Five-Year Defense Plan. (6:16)

The decreased budget included the elimination of ECIP (3:62). Energy projects which would have qualified for special consideration have had to compete with mission requirements for funding. It has become increasingly difficult to fund large energy savings projects.

Another important issue is the current reliance on foreign oil. In 1988 the United States imported 37 percent of the oil consumed. This is a higher percentage of the oil consumed in the United States than at the beginning of the 1973 oil embargo. Assuming a moderate increase in oil usage and the trend towards domestic production loss, this percentage could increase to 55 percent by the year 2000. This equates to 10.2 million barrels of oil per day (1:9). "Another oil crisis is definitely on the horizon (2, 17)." To avoid this, the United States and the Air Force must make further reductions.

Purpose of this Study

General Issue. To comply with the Air Force Energy Plan, the energy conservation officer must be able to identify buildings which are wasting the most energy and implement plans to reduce the waste.

> Using utility and other records, collect data on various forms of energy used. Establish, where possible, the historical consumption profile of buildings and systems to identify how much energy typically is consumed and primary causes of variances. The energy use profile will help in identifying energy conservation options which can be em-

> ployed. This data also establishes the benchmark from which energy reduction goals can be set for the team to work toward. Simply stated, unless you do this, you won't know when your energy conservation job is done for each building. (7:2-2 to 2-3)

The "other records" are historical meter readings. However, "Since 1975, energy reductions have become increasingly difficult to achieve (3:9)." The energy fixes have become much more expensive. To achieve sufficient reduction, the projects now completely replace working mechanical and electrical building systems and renovate otherwise functional facilities.

With fewer and fewer dollars available, the ECON program must target facilities for conservation measures which save the most energy for each dollar invested. This requires tracking many facilities to find those most in need of conservation action. This compels the energy conservation planners to examine hundreds of buildings and utility meter readings to determine how each facility performs.

Specific Problem. The problem dealt with in this thesis, was determining how the information needed for tracking energy consumption of Air Force facilities can be collected, stored and retrieved to optimize the investment in energy conservation. The discussion of the general issue raised many question such as: how to determine which facilities need work or where to get the money for energy conservation projects. However, the first topic to investigate has to be how to collect and process the data needed to determine the best approach to reducing energy waste.

Research Objective. This research develops and implements an energy tracking and reporting system at Wright-Patterson AFB. The information gained can be used to develop a system which might be effective at other bases.

Investigative Questions. To realize the objective of this research the criteria for a tracking system had to be ascertained. The following research questions were used to obtain those criteria.

1. What available data can be used to determine the energy conservation performance of a facility?

2. In what form is the data which will be used for input to the MIS?

3. What information can be developed from the data to compare the energy conservation performance of the Base facilities?

4. What format provides the easiest to use information?

5. Besides energy conservation performance reports, what additional information can be provided from the collected data?

6. Is there any system currently available which will meet the requirements determined in the previous questions?

7. What method is the most appropriate to provide useful information about the energy use pattern of a facility? One possibility is a computer program on the WANG computer system.

8. Can a system defined by the previous questions be implemented AIR FORCE wide?

Scope and Limitations

The outcome of this research was a system for displaying the energy consumption patterns of Air Force facilities. The investigation included evaluations of both manual (using pencil and paper calculations) and computerized systems. The determination on the type of system developed depended upon the results of the research.

The main limitation was that any computer application must run on the WANG Computer System. This computer was chosen to support the Work

Information Management System (WIMS) and is available at most CE organizations. This will provide for the widest possible distribution. The programming languages provided with the WIMS are Basic, Fortran and COBOL (COmmon Business Oriented Language). The intended purpose of COBOL was the development of data management programs and is therefore the logical language to use for this type of program. The author had to learn COBOL to develop any software solutions to this thesis.

Due to time constraints of the AFIT Graduate Engineering Management Program and the data needed for a complete operational test, a prototype system was implemented and evaluated at only one sight, Wright-Patterson AFB.

II. Methodology

Overview

The primary research method used was historical. Literature reviews of public documents, military policies, and military regulations, provided answers to most of the research questions. The remaining answers were developed from interviews with Air Force Personnel who prepare the Defense Energy Information System Report (DEIS II), Air Force Engineering and Services Center Work Information Management System (WIMS) developers, and the personal experiences of the author.

Methodology Justification

The MIS developed in this thesis has to meet the requirements of Air Force regulations and policies, and be compatible with private industry practices. The author gathered data from documents as to the information contained on different utility company billing forms, the various energy reports required by Air Force regulations, and the energy reports required by Air Force Regulations and Policies. Previous attempts at developing energy tracking systems were reviewed.

Historical research is the consolidation of information about a given topic and the development of a coherent picture on the current state of knowledge about that topic. The researcher examined what has been done to define the problem and what has been proposed as solutions to the problem. The research reviewed previous research and applied inductive logic to formulate a proposed solution to the problem. The final step was to test the hypothesis. This resulted in new knowledge (8:48-49).

Since past events produce the information used as the basis for the solution, the relevance of the results of this report is dependent upon on the reliability of the sources and the validity of the information.

The first criterion, source reliability or external appraisal, was authenticating the source. Can the source be proven to be what it claims to be? To satisfy this requirement, the documents used for this report came from recognized publications such as professional journals, reputable trade journals and government documents and reports.

The second criterion, content validity or internal appraisal, was verifying the information obtained from the source. To satiate criticism, the critical information was supported by other sources that report the same or similar results; these additional sources also met the requirement for source reliability. (9:148, 153)

There are two dangers in using the historical methodology, insufficiency of data and improper selection of data (9:159). To overcome these problems, the researcher made an effort to do a thorough literature review and to incorporate all pertinent data. While this does not guarantee information was not overlooked, it does increase the rigor of the methodology.

In conjunction with the literature search, telephone interviews were conducted with 17 randomly selected bases. The initial list of interviewees was developed from lists provided by the Major Command Staff of Air Training Command, Military Airlift Command, Strategic Air Command, and Tactical Air Command. These interviews were used to determine the current procedures used at base level organizations. The exact questions used for the interviews are provided as Appendix A.

Research Questions

The criteria used to develop the energy tracking system was established by the answers to the eight questions below.

Investigative Question 1.

What available data can be used to determine the energy conservation performance of a facility?

The purpose of this question was to determine what type of data needs to be collected to enhance the evaluation of a facility's energy consumption.

Two avenues were pursued as sources for information. First, the literature review provided information on what has been shown to have significant impact on building energy consumption. The second source was the interviews of selected base level Energy Conservation Officers. This step reinforced the first and gave a picture of what data is gathered today.

Investigative Question 2.

In what format is the data which will be used for input to the MIS?

The intention of this question was to decide what is needed to manipulate the data once it has been collected in the database. Data has to be standardized to allow direct comparison.

Base level Energy Conservation Officers and the Air Force Engineering and Services Center (AFESC) answered this question. Through the use of interviews, information about the data gathered at base level was obtained. The AFESC provided a program manual developed for a different computer system. The manual contained information about the type of data found on utility bills.

Investigative Question 3.

What information can be developed from the data to compare the energy conservation performance of the Base facilities?

Once the data had been gathered and standardized, the intention was to develop some information which can be used to manage the Energy Conservation Program. The literature review of Air Force regulations and reports on factors which effect energy consumption provided the measures needed to determine energy consumption at both the base level and the facility level.

Investigative Question 4.

What format provides the easiest to use information?

Even with the most complete database, sometimes the true usefulness is hidden because the information is presented in incomprehensible form. The literature of research on human and computer interfaces provided information on how to formate the information to make it the easiest to read and comprehend.

Investigative Question 5.

Besides energy conservation performance reports, what additional information can be provided from the collected data?

Some of the data gathered to monitor energy consumption are used for other activities and reports. This research of the Energy Program presented an opportunity to increase the productivity in Civil Engineering by eliminating redundant handling of data.

A review of the uses of the data provided the information on the reports needed at base level and at the Major Commands.

Investigative Question 6.

Is there any system currently available which will meet the requirements determined in the previous questions?

Literature review and interviews were used to determine if any system was available which could meet the needs defined by the previous questions. A predominate requirement was that any system had to be usable to generate the reports required of Civil Engineering's Personnel.

Investigative Question 7.

What method is the most appropriate to provide useful information about the energy use pattern of a facility? One possibility is a computer program on the WANG computer system.

This question was to determine if a manual or computerized system would be the most efficient method of handling the data. This included the generation of the reports associated with the energy conservation program. The answers were determined from the telephone interviews with Base Level Energy Conservation personnel.

Investigative Question 8.

Can a system as defined by the answers to the previous questions be implemented AIR FORCE wide?

A common system would provide a means of sharing information and techniques between Energy Conservation Officers. It could also enhance training method by providing a standardized system.

The interviews of the Energy Conservation Officers provided the answer to this question by highlighting any major differences between the type of data collected and reported to command level agencies.

III. Findings

Overview

The purpose of this chapter is to detail the finding of the research portion of this thesis. To accomplish this, the investigative questions which were outlined in Chapter II and the structure of the developed MIS are discussed.

Research Questions

Investigative Question 1.

What available data can be used to determine the energy conservation performance of a facility?

The basic information needed to monitor energy usage is the quantity of energy consumed by the facility or base. However, most of the facilities are not metered. The Air Force requires bases to meter 35 percent of the base square footage, but that is inadequate. Many facilities are lumped together and an individual facility's energy usage cannot be measured (10). Furthermore, the majority of the metered facilities are new and should therefore be the most energy efficient. While the older buildings, were most of the potential gain exists, are less likely to be metered.

The size, use, and design of a building are the predominate factors which control the amount of energy that building will use. When these factors are combined with the number of occupants, the actions of the occupants and the effects of the weather, energy consumption predictions accurate enough to meet the current Air Force goals are nearly impossible. There is no perfect correlation between energy consumption and any other factor effecting energy usage (11). For some facilities weather data in the form of Heating Degree Days (HDD) and Cooling Degree Days (CDD) follows the general trend of energy consumption (12:114). A system used to analyze the consumption of energy in facilities needs to include HDD and CDD.

The interviews yielded the same information as gathered from the documents reviewed. Besides quantity and temperature data, both of which are currently tracked in the Energy Conservation Program, no additional data is used to analyze energy consumption.

Investigative Question 2.

> In what form is the data which will be used for input to the MIS?

This question was answered in two parts. Some facility consumption information is gathered by base personnel. Additional information is provided by the utility companies on the monthly utility invoices.

The data gathered at base level is either meter reading, consumption numbers taken from an Energy Monitoring and Control System, or Engineering estimates of consumption. The system needs to be able to handle both types of entries.

The utility bills come with many different pieces of data and in various forms, depending on the company and the type of utility provided.

Electricity can be charged by demand level, consumption quantity, reactive power, fuel charges and various other miscellaneous charges. There can also be rebates for past over charges.

Demand, consumption and reactive power charges can all be calculated using several methods. There are at least three methods for structuring the demand rate schedule and two ways of determining the billing demand.

The first demand rate structure is simply a flat fee for each Kilowatt (kw) of the highest demand experienced during the billing cycle. The second method, called Block-Hopkinson Demand Rate Schedule, charges different prices for different blocks of kw used. As an example, the cost maybe $1.00 per kw for the first 100 kw demand, $1.50 per kw for the demand between 100 kw and 200 kw, and $2.00 per kw for all kw over 200. Finally, there is the Time of Day Demand Rate Schedule. Under this billing method the charge is based on the time of day the peak demand (highest demand experienced in the billing cycle) occurred. The actual rate structure can be either a flat fee or a blocked fee schedule. All of these rate schedules can also be structured so that prices differ seasonally.

The different methods by which the demand charge can be calculated are further complicated by having two methods for calculating the billing demand. The most straight forward is to use the actual peak demand recorded during that billing period. The more energy being used at a given instant in time the higher the demand and hence the higher the bill. The other method sets a minimum demand level and is used for cost calculation if the peak demand does not exceed that level. This minimum level can be set at a specific value in the contract or can be fixed as a percentage of a past peak demand.

Electrical consumption charges can be calculated from a flat or a blocked rate structure. Quantity is strictly determined by the amount of electricity used during the report period, as measured in Kilowatt Hours (kwh). It is not common for utility companies to charge different consumption rates at different times of day. This would require multiple meters or meters with dual recording capability.

The meters used on the electrical system use voltage and amperage to determine the amount of power being used by the customer. Because motor, transformers, and other types of equipment change the relationship between voltage and amperage the measured quantity can be different from the amount actually used. This difference is called reactive power. Reactive power can be charged at a flat fee or it can be added to the recorded demand to increase the billed demand. To determine the reactive power, readings are kept on the power factor of the metered demand. Power factor is the cosine of the angle (θ) between the actual power in kilo Volt Amperes (kVA) and the real power measured in kW (see Figure 2.). Reactive power is demand multiplied by the tangent of θ. While the actual methods for calculating the quantity of the reactive power which is chargeable are numerous, 4 methods are discussed in this study.

The first method is to charge for all the reactive power. The second is to charge for only the amount of reactive power above a percentage of the peak demand (see Equation (1)). The third method is to multiply the demand charge by a factor which is calculated as a ratio of the contact allowed power factor to the actual power factor for the billing period (see Equation (2)). The final method is to take the

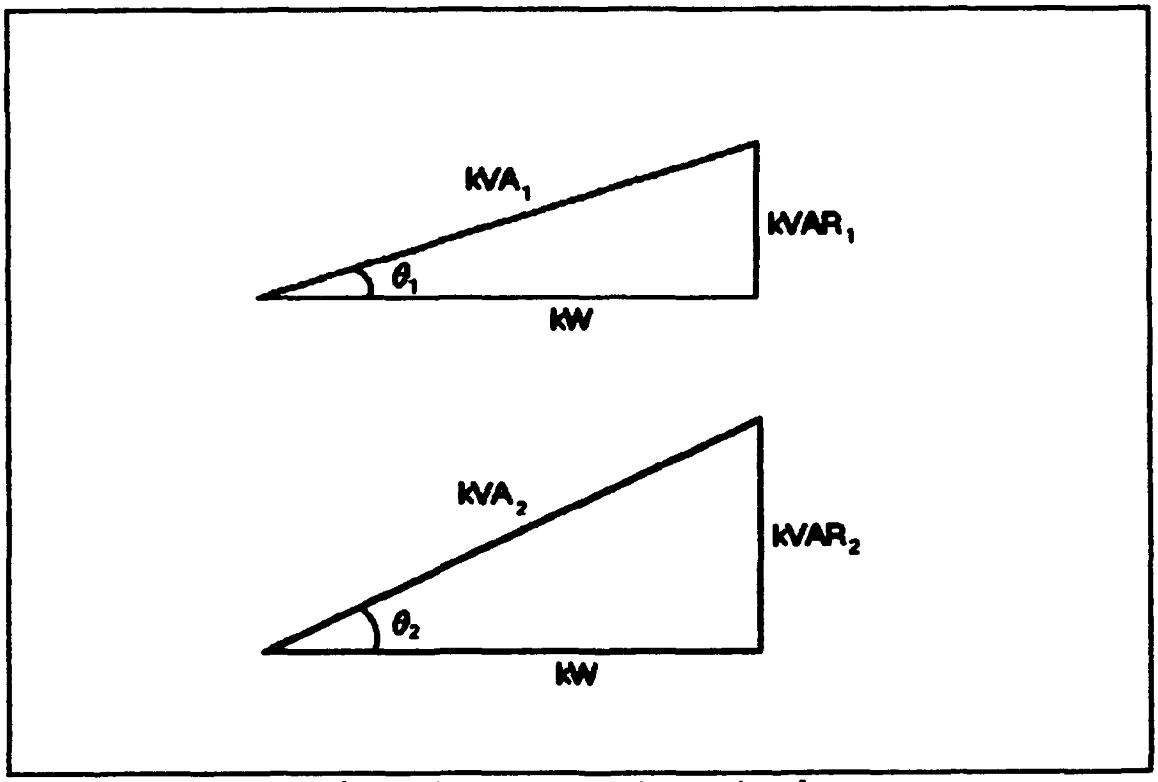

Figure 2. Power Factor Triangles

difference between the allowed reactive power and the actual reactive power (see Equation (3)).

$$\textit{Charged kVAR} = \textit{kVAR} - (\textit{Demand} \times \textit{Contract Percentage}) \tag{1}$$

$$\textit{Charged Demand} = \textit{Demand} \times \frac{\textit{Contract Power Factor}}{\textit{Actual Power Factor}} \tag{2}$$

$$\textit{Charged kVAR} = \textit{Demand} \times (\textit{Tan}(\theta_2) - \textit{Tan}(\theta_1)) \tag{3}$$

where

$\theta_1 = \cos^{-1}$(Contract Power Factor)
$\theta_2 = \cos^{-1}$(Actual Power Factor)

The final item common on electric invoices, which might need calculation, is the fuel charge. When it occurs, this item is to provide the utility company a method to pass on the increased or decreased cost for their primary fuel source. The term fuel charge is somewhat of a misnomer. In some contracts this term not only allows for a fluctuation in fuel cost, but it also provides the utility companies a way to recoup any excess costs associated with the production of their product.

There are other varied charges used infrequently with some electricity invoices. They vary widely and any database capable of handling all would be to cumbersome. Instead of producing specific fields for each of these unique charges, general areas are needed to allow for the incorporation of this miscellaneous data.

The natural gas bill, in comparison to the electric invoice, is very simple. The major problem is that there are three different measurement units which can be used to compute the bill. The first, cubic feet, is a unit of volume and is taken directly from a meter. The other two measures, therms and British Thermal Units (BTU), are units of energy and deal with the quantity of energy contained in a specific volume of natural gas. These units cannot be metered; they must be determined from laboratory tests. The approximate relationship is

$$1\ cf = 1\ therm = 1000\ BTU's\ (1\ mBTU)$$

Facility gas meters are read using cubic feet and require a conversion factor between the unit used for the utility bill and the volume measurement taken from the facility meters. Other than this conversion, the calculation of the natural gas cost is simple. Consumption is charged at a flat rate or under a blocked rate structure and there are no demand charges. There is the possibility of a fuel charge or other miscellaneous charges.

The water bill is the final invoice considered in this study. Though not an energy concern, it is a critical resource and fits into the structure of this system. With water, there is basically a consumption charge with possible additional miscellaneous charges.

Investigative Question 3.

> **What information can be developed from the data to compare the energy conservation performance of the Base facilities?**

This is the heart of the energy conservation program. As mentioned in Investigative Question 1 there is no exact match between external influences and energy consumption. However, some facilities show a very high correlation between Degree Days and energy consumption. These are the non-industrial facilities, especially housing units (12:114). The general energy characteristics of a facility can be determined and compared to other similar facilities. More importantly, the usage pattern for a specific facility can be tracked to determine if it starts to deteriorate. Both of these techniques can assist in determining if work needs to be done on a facility.

Even the lack of correlation between weather and energy consumption gives basic information about the facilities energy usage pattern. By knowing the weather has little effect on the facility, the ECON personnel can concentrate on different ways to reduce energy consumption in that facility. Also, if the facility starts to show a correlation between weather and energy consumption the energy conservation personnel will be queued to look at that facility to locate the what caused of the change.

Using the basic information provided by energy consumption, facility size, and weather data (HDD and CDD), the energy conservation personnel can determine which facilities show the greatest promise for energy savings. In addition, they will know the most likely characteristics to modify to achieve a reduction in energy usage. The system must track the consumption, facility size, and Degree Days.

Investigative Question 4.

> **What format provides the easiest to use information?**

The input format and the resultant output of the reports from this system both effect the usefulness of the system. This discussion does not include hardware changes. The structure of the input should be such that it follows the natural flow of information within the organization (13:28). This means the data should be entered at the most logical point and the information should be available were it is needed.

Additionally, the structure of the program should facilitate data entry. The AFESC WIMS programmers developed a standard format for database programs. This is to make use of the program function keys consistent between application and to make transition between applications easier. (The complete explanation for this system is in the School of Engineering and Services MGT 003 - ESIMS Administrator Course Guide Source Generator.)

The output of the system should be such that it provides flexible information where and when it is needed. The WIMS provides a report utility which, when used with the databases on the VS, allows each user to tailor reports to their specific need. The output reports should be clear, concise, and usable. The best method would include some graphical presentation.

> Neither columns and rows of statistics in tabular arrangement nor the seemingly endless listings of figures in textual form can possess the clarity, appeal, or meaningfulness of a well-designed chart. By emphasizing important salient relationships, graphs and charts may also be of immense service in the location and definition of problems and in the discovery of hidden facts. (14:v)

The graphical representation provides more information in an easier to understand format.

<u>Investigative Question 5</u>.

> **Besides energy conservation performance reports, what additional information can be provided from the collected data?**

There are at least four other uses for energy conservation data. The first is the billing of reimbursable customers. The second is to assist in the preparation of annual utility contract reviews. The third is for monthly upward reporting on utility funds. And finally data can be used for preparing testimony in utility rate cases (15).

The billing system is a basic function which allocates the cost of utilities to agencies which are separately funded. This mainly deals with housing, hospitals, the Air Force Commissary, the Army Air Force Exchange, Moral Welfare and Recreation activities, other governmental agencies, and non-governmental organizations (16:3). The utility meter readings needed to charge these activities for consumption are available in the energy conservation program. Recording the meter readings once eliminates redundant handling of these meter readings and could reduce the work load associated with preparing the reimbursable bills.

The second common report is the yearly utility contract review. The utility bills are reviewed and the consumptions summed to present a picture of the total energy usage and the costs associated with a specific contract. This information is used in evaluating the terms of the contract to determine if the contract needs to be changed or updated. Again, most of the information for this report is gathered from data previously collected for the energy conservation program.

The third item is not common to all major commands. Some commands request monthly or quarterly reports from their subordinate units. An energy MIS has the potential to eliminate redundant handling of information for periodic reviews. This report tracks the amount of the energy budget which has been used and the amount of money earned from the reimbursable customers. Periodic reports fit with the billing system.

The finial use is to determine the effect of a requested rate increase on the Government Installations which are serviced by the requesting utility company. Currently the data needed to prepare for these rate cases has to be gathered from each base under contract with the requesting utility company after the company announces it is seeking a rate increase. This is a time consuming process. First, the effected installations need to be identified and then the organization handling the analysis needs to contact the installations to get the necessary information. The energy MIS database could eliminate this by providing a source for data for future utility rate cases that constantly up dated as the changes occur.

Investigative Question 6.

What method is the most appropriate to provide useful information about the energy use pattern of a facility? One possibility is a computer program on the WANG computer system.

From the interviews it was discovered that 12 of the 15 respondents currently use a computer system. They report that the system saves them, on average, 65 percent of the time they would need to generate their reports manually. This highlights the performance benefits gained by using a computer system to do data processing.

While no specific question was asked regarding which sections of the organization performs which specific tasks, several interviewees said the person preparing the DEIS II report handled only a portion of the overall job. There is a split between those taking the meter readings, those preparing the DEIS II report, and those who monitor the budget.

The shop personnel are generally responsible for taking the meter readings. The readings are then used by the energy conservation personnel to prepare the DEIS II report and either the same person or, as in six of the bases surveyed, someone else prepares the other reports. This variety shows the use of the system needs to be decentralized. On the other hand, to reduce the number of times information is handled the system needs to have centralized data storage.

Investigative Question 7.

Is there any system currently available which will meet the requirements determined in the previous questions?

The current practice where each base develops their own system seems to comply with the requirements. It may not be the most efficient way. But, each system is tailored for that base and major command.

There are many draw backs to the current system. With such a variety of systems, it is hard to share techniques for analyzing data. And any comparison between bases is questionable. While some of the bases have benefitted from people who were capable of creating integrated systems which minimize the work load, others have only developed fragmented systems which help in one area but do not minimize redundancy. Even at bases where an effective system was developed, software maintenance and modifications become irritating problems.

There are several PC based energy tracking programs available in the commercial realm. One such program, FRASER from Omni Corp, is currently being used at Lackland AFB. Being a PC system restricts the usefulness by placing access to the system in a single area of the organization. FRASER does not offer decentralization or networking capability.

There is no system currently available that meets the full requirements of the system described by the research and envisioned by the author.

Investigative Question 8.

Can a system as defined by the answers to the previous questions be implemented AIR FORCE wide?

A system is possible at the bases within CONUS. The basic guidance of the energy conservation system is AFEPPM (Air Force Energy Program Policy Memorandum) 86-8 and the basic guidance for the utility services is AFR 91-5. Since all CONUS bases are covered by the same requirements, the same basic information, and the same data sources, the differences between bases are in the structure of their reports. All CONUS bases collect common data and report in similar frequency and format. Each command must deal with a variety of utility companies bill structures. Since the reports generated for each command can be tailored to meet their requirements these differences pose no problem. However, the structure of the utility bills can limit the applicability of this system. The final answer must wait until a system resulting from this study is placed in a large scale test.

System Structure

Most of the needs identified from the answers to the preceding questions are incorporated into the MIS. The needs identified but not included in the MIS are described later in this report. Those items which are incorporated fall into two broad categories, data collection and data manipulation.

Data collection includes collecting, storing, and upward reporting. The MIS has a decentralized data entry design which allows multiple offices to interact with the databases. It also has centralized data storage permitting all users access to the complete data set. Finally, the system has the capability for upward reporting.

Data Manipulation encompasses invoice verification, unit conversion, consumption calculation, and resource allocation. The system checks utility invoices against charges calculated from contract terms. It also takes consumption data from the utility invoices and converts it into units required for Air Force reports. For facilities, the system calculates consumption from meter readings and charges only a specified percentage of the consumption against that meter. To facilitate report preparation, the system has the capability to allocate the consumption and cost from each invoice and facility meter in three different ways.

The system which resulted is a collection of three programs and three reports for the WANG VS computer system. The purpose for creating three programs followed the break down of the natural flow of information and the structure of the input data. The first program, UVERUD, deals with the Utility Contract Data. This program includes the rate structure and the general information on the contracts. The second program, UBILUD, handles the monthly utility invoices received from the local utility companies. This program verifies and stores the invoice data. The final program, UMETUD, handles the facility data. This includes the facility meter readings and some general information on the allocation of the resource.

The reports are used for billing reimbursable customers (BILL), developing input information for the DEIS II report (DEIS), and developing information used to track utility budget expenditures (UTIL).

Programs

User Screens. The programs were developed to include two screen types, directory screens and information screens. The directory screens are not updatable. They provide a means for finding a specific data record. To facilitate the presentation of these screens data records are provided to illustrate the format of the data types, this data is not coded into the program.

The information screens are updatable and the format used in this report to indicate the type of data accepted in each field would not be seen on the computer screen. To indicate that numeric data is allowed the field is displayed using underlines, to indicate an alphanumeric field a capital x (X) is used, and 9 is used to indicate a computed field.

UVERUD. This program (see Screen 1) provides the data entry interface for the utility contract database. The purpose for this database is two fold. First the data are used by the Air Force to analyze the impact of a requested rate increase on the Air Force. The information needed for the analysis is available and stored in a central database. With the contract data available in a common form, upward reporting to a central database is simplified. This allows quicker response time to requests for rate increases.

This database is also used at a local level to allocate and verify the cost and consumption of the monthly utility invoices (see Screen 2). The fields which control allocation are utility classification, energy category, and primary user . These fields determine how the portion of the utility invoice which is not otherwise distributed by a specific

```
   Active              Utility Contracts Billing Data Updater

  Start Date        Contract Number        End Date  Consolidated Bill
 ______________________________________________________________________

 _ 90/07/01  1000000000000000001000100                  G01
 _ 83/06/29  5521000000237000022000900                  E01
 _ 83/06/29  5521000000237000022001000                  E01












Position the cursor and press ENTER to display the entire record.
(1)Keys                                                        (8)Find
(9)Modify(10)Query (11)Add   (12)Delete(13)Help  (14)Path  (15)Print (16)Retrn
        (26)Merge  (27)Extrct(28)Move  (29)Info  (30)Histry(31)Rpts
```

Screen 1. Utility Contract Directory (UVERUD)

facility meter reading or consumption estimate will be handled. While all these fields allocate a portion of the consumption and cost, these three fields are used to produce different reports. The utility classification field is used to monitor the allocation of the utility budget. The energy category field is used to monitor the energy conservation targets. The primary user field is used to charge the appropriate agency for the cost of the utility they consumed during that month.

Other data stored in this database are the information needed to calculate consumption (the meter capacity and the meter multiplier) and

```
                    Contract Billing Information Screen

      Installation Code:  XXXX                               Revision: __
      Contract #: _____________     Schedule: ____      Change #: ____

      Company Name:   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

      Primary User: XXXXXXXXXX      Utility Classification: XXXXXXXX

      Energy Category: XXXXXXXXXX          Consolidated Bill #: X __

      Customer Charge: ______.__             (M)inimum or (B)ase: X

      Meter Capacity: _________             Meter Multiplier: _____

      Minimum Load: ______.__                         Rate: __._____

         Remarks: __________________________________________

         Effective Dates (YY/MM/DD) - Start: _______   End: _______
 ------------------------------------------------------------------------
 (1)Keys            (3)Desc            (5)Next                    (8)Find
 (9)Modify(10)Query (11)Add    (12)Delete(13)Help         (15)Print (16)Retrn
                               (20)Screen(29)Info                   (32)Exit
```

Screen 2. Utility Contract General Information (UVERUD)

to determine the monthly bill (customer charge, minimum load rate structure, reactive power calculation method, and maximum demand).

The rate data stored in this database are used by the program UBILUD to verify the utility invoices (see Screen 3).

<u>UBILUD</u>. This program (see Screen 4) provides the interface for the monthly invoice database. It is updated at regular intervals. The data for the electric, natural gas, and water invoices are stored in this database. The result is a database which contains all the information necessary to calculate the basic unit cost of the utilities. This database also contains the actual base consumption information.

```
                          Rate Structure Screen

    Normal (excludes High Season)             High Season   From 00 to 00
                       Block-Hopkinson Demand Rate Schedule
 Consumption    Cost   Demand   Cost     Consumption    Cost   Demand   Cost

 ________.__ __.______ _____ __.______   ________.__ __.______ _____ __.______
 ________.__ __.______ _____ __.______   ________.__ __.______ _____ __.______
 ________.__ __.______ _____ __.______   ________.__ __.______ _____ __.______
 ________.__ __.______ _____ __.______   ________.__ __.______ _____ __.______
                            Time of Day Demand
      On Peak          Off Peak              On Peak          Off Peak
   Demand    Cost    Demand    Cost      Demand    Cost    Demand    Cost

   _____  __.______  _____  __.______    _____  __.______  _____  __.______
   _____  __.______  _____  __.______    _____  __.______  _____  __.______
   _____  __.______  _____  __.______    _____  __.______  _____  __.______
   _____  __.______  _____  __.______    _____  __.______  _____  __.______
   Ratchet Clause                                 Minimum PF: _.__
   Maximum Demand: _____.__ Schedule:             Verification Method: __
   Billing Demand: _.__  % of Maximum Demand      KVAR Charge: ___._____

 ____________________________________________________________________________
 (1)Keys          (3)Desc            (5)Next                         (8)Find
 (9)Modify (10)Query (11)Add  (12)Delete(13)Help          (15)Print (16)Retrn
                  (20)Screen         (29)Info                        (32)Exit
```

Screen 3. Utility Contract Rate Structure (UVERUD)

Using the UBILUD database in conjunction with the UVERUD database provides a method for verifying invoice price data are correct.

On the input screen for the electric invoices (see Screen 5) fields are provided to identify the meter used for determining consumption, the contract under which the rate structure is based, and the actual billing information. The billing data includes the meter reading, consumption, billing period peak demand, two fields for reactive power so that it can be entered as kVAR or as power factor, fuel charges, rebates, four fields for miscellaneous charges, and costs associated with each of these items as well as an overall cost.

```
    Active                    Monthly Utility Bill Updater

   Date  Meter#      Contract Number
 ___________________________________________________________________________

 _ 8910  000001  55210000002370000220010 00
 _ 8910  010001  1000000000000000001000100
 _ 8910  020001  2000000000000000001000100
 _ 8911  000001  5521000000237000022001000
 _ 8911  010001  1000000000000000001000100
 _ 8911  020001  2000000000000000001000100
 _ 8912  000001  5521000000237000022001000
 _ 8912  010001  1000000000000000001000100
 _ 8912  020001  2000000000000000001000100
 _ 9001  000001  5521000000237000022001000
 _ 9001  010001  1000000000000000001000100
 _ 9001  020001  2000000000000000001000100
 _ 9002  000001  5521000000237000022001000
 _ 9002  010001  1000000000000000001000100
 _ 9002  020001  2000000000000000001000100

Position the cursor and press ENTER to display the entire record.
(1)Keys                             (5)Next              (7)Up     (8)Find
(9)Modify(10)Query (11)Add  (12)Delete(13)Help (14)Path (15)Print (16)Retrn
        (26)Merge (27)Extrct(28)Move  (29)Info (30)Histry(31)Rpts
```

Screen 4. Monthly Utility Bill Directory (UBILUD)

On the input screen for the natural gas invoices (see Screen 6) the same fields are provided as under the electric invoice with minor exceptions. Reactive power and demand are not included. The additions have to do with calculating the amount of energy contained in a quantity of natural gas. The basic unit of measure for natural gas is assumed to be in cubic feet. Two fields have been incorporated to allow for billing based on energy potential and for reporting the quantity of MBTU's consumed.

Finally on the input screen for the water invoice (see Screen 7) only the fields dealing with identifying the meter and the contract

```
                    Monthly Bills - Electricity

    Meter #: _____      Report Date: ___    Billing Date: _______
    Contract #: ____________   Schedule: ___    Change #: ___
    Revision #: _
   Meter Reading: ________._           On Peak Demand: X (Y for yes)
   Consumption: ________._                        Cost: _______._
   Peak Demand: _____._                           Cost: _______._
   Peak Reactive Power: _____._
   Power Factor: _.______                         Cost: _______._
   Fuel Charges: __.____   (per unit)             Cost: _______._
   Remarks: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX    Rebate: _______._
   Other Charges:              Reason                  Charge
                 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX  ______._
                 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX  ______._
                 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX  ______._
                 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX  ______._

                                                Cost: ________._
                                     Calculated Cost: ________._
 ______________________________________________________________________
 (1)Keys            (3)Desc            (5)Next                  (8)Find
 (9)Modify(10)Query (11)Add   (12)Delete(13)Help     (15)Print (16)Retrn
(17)Verify                             (29)Info                 (32)Exit
```

Screen 5. Monthly Electricity Invoice (UBILUD)

along with the fields for meter reading, consumption, rebate, miscellaneous charges, and cost of each of these item and the total cost have been included.

The verification portion of this program checks the calculation of utility company invoices to insure their accuracy. This includes consumption, if meter readings are available, and the calculated costs of all individual items. If any of the individual items are wrong, a message describing the error appears on line twenty of the input screen. Total cost is not checked by the computer, but a calculated value for total cost is displayed below the value input by the user. This allows

```
                    Monthly Bills - Natural Gas

     Meter #: _____      Report Date: ___     Billing Date: _______
     Contract #: _____________      Schedule: ___     Change #: ___
     Revision: _
   Meter Reading: ________._
   Consumption: ________._
   Correction Factor: __._____
   Corrected Consumption: ________._                Cost: _______._
   MBTU Factor: __._____
   Fuel Charges: ___._____  (per unit)              Cost: _______._
   Remarks:                                       Rebate: ______._
   Account Charges:              Reason                   Charge
                  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   ______._
                  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   ______._
                  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   ______._
                  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   ______._

                                                  Cost: _______._
                                       Calculated Cost: _______._
 ____________________________________________________________________
 (1)Keys  (2)First (3)Desc  (4)Prev  (5)Next                  (8)Find
 (9)Modify(10)Query (11)Add  (12)Delete(13)Help     (15)Print (16)Retrn
(17)Verify                           (29)Info               (32)Exit
```

Screen 6. Monthly Natural Gas Invoice (UBILUD)

the user to determine the magnitude of the cost difference.

UMETUD. This program (see Screen 8) is the data entry mode for updating the database which contains the facility meter readings. Similar to the other programs, the first screen is the directory screen. Each meter has two additional screens, one containing general information about the meter and the other containing consumption data.

The general information screen (see Screen 9) provides the updatable fields useful for tracking, allocating, and manipulating the meter readings. The fields used for tracking include the facility were the meter is located, a description of the facility, a unique designator

```
                         Monthly Bills - Water

     Meter #: _____       Report Date: ____     Billing Date: _______
     Contract #: _____________      Schedule: ___      Change #: ___
     Revision: __

   Meter Reading: ________._
   Consumption: ________._                             Cost: _______._
   Remarks: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX          Rebate: _______._

   Account Charges:              Reason                     Charge
                  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX      _______._
                  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX      _______._
                  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX      _______._
                  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX      _______._

                                                 Cost: ________._
                                      Calculated Cost: ________._

(1)Keys   (2)First  (3)Desc   (4)Prev   (5)Next                  (8)Find
(9)Modify(10)Query (11)Add   (12)Delete(13)Help        (15)Print (16)Retrn
(17)Verify                            (29)Info                   (32)Exit
```

Screen 7. Monthly Water Invoice (UBILUD)

for this meter, and the beneficial occupancy date (BOD). The fields used for allocating the energy metered are utility classification, energy category and customer name.

The final set of fields determine how much consumption is associated with a specific meter reading. How much of metered quantity is allocated to this user (17). And whether this is a sub-meter (this metered quantity is a portion of the quantity accounted for under another meter) (18).

Two different screens exist for entering consumption data. The first screen (see Screen 10) allows the user to enter the actual meter

```
Active          Meter Reading for Base Facilities

   Bldg    Meter  Category    BOD      Customer    Consolidated Bill

 _ 10274   E001   Base       850101    Base            E01
 _ 10830   E001   Base       851010    Hospital        E01
 _ 11435   E001   Base       850901    Base            E01
 _ 99998   G002   Housing    850101    Housing         G01
 _ 99999   G001   Base       850101    Base            G01













Position the cursor and press ENTER to display the entire record.
(1)Keys                                                        (8)Find
(9)Modify(10)Query (11)Add  (12)Delete(13)Help (14)Path (15)Print (16)Retrn
                            (28)Move  (29)Info (30)Histry(31)Rpts
```

Screen 8. Facility Meter Directory (UMETUD)

reading. The program calculates the consumption based on this reading and the previous months meter reading. The consumption information is displayed in the indicated locations. In addition, the date of the reading is required to trigger the consumption calculations. This function is programmed in for two reasons. First, it provides the opportunity to calculate the number of degree days between meter readings, instead of the current method of using the degree day readings for the calendar month. Second, the program uses this field for not calculating consumption for the meter readings not yet entered. The reading date field is left blank until a reading is made. The computer,

```
                         BASIC METER DATA

Facility: _____         Facility Description: XXXXXXXXXXXXXXXXXX

Meter Number: X ___                              BOD: _______

Utility Classification: XXXXXXXXXX       Facility Size: ______

Customer Name: XXXXXXXXXX            Energy Category: XXXXXXXXXX

Multiplier: _____             Maximum Meter Reading: ________

Percentage of Metered Usage Applied to This Account: _.___

Is this a Master Meter: X      Master Meter Number: _____ X ___

Consolidated Bill Number: X ___    (R)eading or (C)onsumption: X

____________________________________________________________________
(1)Keys            (3)Desc
        (10)Query                 (13)Help            (15)Print (16)Retrn
                        (20)Screen(29)Info                      (32)Exit
```

Screen 9. Facility Meter Data (UMETUD)

sensing a blank field, will not subtract the current months reading from next months reading (defaulted to zero) thus avoiding a negative consumption.

Because other methods exist for determining consumption besides reading from a traditional meter, this program permits the direct entry of consumption (see Screen 11). Two methods which need this capability are readings taken from an EMCS system (18) and estimates based on engineering principles (2, 17).

This database, unlike UBILUD, also contains the fields necessary for allocating the metered consumption. This was done for two reasons.

```
                         METER READING SCREEN

     Facility: ____        Facility Description: XXXXXXXXXXXXXXXXXX
     Meter #:  X __                                Fiscal Year: __
             Reading            Consumption       Date Read (yy/mm/dd)
      Sep   _______._          ___________              _______
      Oct   _______._          9999999999               _______
      Nov   _______._          9999999999               _______
      Dec   _______._          9999999999               _______
      Jan   _______._          9999999999               _______
      Feb   _______._          9999999999               _______
      Mar   _______._          9999999999               _______
      Apr   _______._          9999999999               _______
      May   _______._          9999999999               _______
      Jun   _______._          9999999999               _______
      Jul   _______._          9999999999               _______
      Aug   _______._          9999999999               _______
      Sep   _______._          9999999999               _______
              Consumption for this FY to date: 99999999999

  Make your modifications and press ENTER.
  (1)Keys             (3)Desc
          (10)Query                    (13)Help          (15)Print (16)Retrn
                           (20)Screen(29)Info                      (32)Exit
```

Screen 10. Facility Meter Readings (UMETUD)

One, the amount of data needed monthly for each of the meters is small. This small size allows each record to contain a full years data. The overhead needed to include allocation data was negligible and the simplicity gained by placing all the data associated with a specific meter in one updater provides advantages when creating reports. Two, since in some cases different organizations occupy the same facility the ability to associate meters and organizations is necessary.

Reports

BILL. This is the report (see Screen 12) used to calculate the charges to be assessed to the separately funded agencies. The user only

```
                       METER READING SCREEN

Facility: ____          Facility Description: XXXXXXXXXXXXXXXXXXX
Meter #:  X __                            Fiscal Year: __
      Reading              Consumption          Date Read (yy/mm/dd)
  Sep                      __________            ________
  Oct                      __________            ________
  Nov                      __________            ________
  Dec                      __________            ________
  Jan                      __________            ________
  Feb                      __________            ________
  Mar                      __________            ________
  Apr                      __________            ________
  May                      __________            ________
  Jun                      __________            ________
  Jul                      __________            ________
  Aug                      __________            ________
  Sep                      __________            ________
          Consumption for this FY to date: 99999999999

Make your modifications and press ENTER.
(1)Keys           (3)Desc
     (10)Query                    (13)Help         (15)Print (16)Retrn
                    (20)Screen(29)Info                       (32)Exit
```

Screen 11. Facility Meter Consumption (UMETUD)

needs to determine which month to calculate, the remaining information should have been supplied in the three databases discussed above. This report prepares only one months at a time.

UTIL. This report (see Screen 13) tracks budgeting information. It tracks how much has been spent from the different utility funds. For most bases these include the base utility budget and housing budgets. It also calculates how much of the reimbursed money has been earned. This report can calculate by month or by quarter and includes an accumulative field for the current and previous report periods.

Facility Billing Preparation

Fiscal Year: 90

_ OCT
_ NOV
_ DEC
_ JAN
_ FEB
_ MAR
_ APR
_ MAY
_ JUN
_ JUL
_ AUG
_ SEP

Position the cursor and press ENTER to select report period.

(16)Retrn

Screen 12. Facility Billing Month Selection (BILL)

DEIS. This report (see Screen 14) calculates information about the utilities encompassed by this system which is needed for the DEIS II report. The different energy categories are reported separately. The information used to separate this data is contained in the fields energy categories and BOD in the program UMETUD.

Items Excluded from Current Implementation. While it would be ideal for the system to include all the options discussed in this research, several items are omitted. These items fall into two categories, things which would be nice to have, but which would not be necessary for the initial test and things beyond the programming skill

Utility Allocations

Fiscal Year: 90

_ OCT
_ NOV
_ DEC
_ JAN
_ FEB
_ MAR
_ APR
_ MAY
_ JUN
_ JUL
_ AUG
_ SEP
_ QTR 1
_ QTR 2
_ QTR 3
_ QTR 4

Position the cursor and press ENTER to select report period.

(16)Retrn

Screen 13. Utility Budget Period Selection (UTIL)

of the author.

The first item left out is the degree day database. The lack of this capability does not restrict the system from achieving results comparable to the current techniques. It can easily be added after the system is successfully tested.

Another major item excluded is the ability to display the output information in a graphical form. There are two problems with using graphical format for reports under this implementation. The first is the limited number of graphical terminals at CE organizations. This would require the purchase of new equipment or the reallocation of the

```
                    DEIS II Input Preparation
_________________________________________________________________

                         Fiscal Year: 90
                            _ OCT
                            _ NOV
                            _ DEC
                            _ JAN
                            _ FEB
                            _ MAR
                            _ APR
                            _ MAY
                            _ JUN
                            _ JUL
                            _ AUG
                            _ SEP



Position the cursor and press ENTER to select report period.
_________________________________________________________________
                                                        (16)Retrn
```

Screen 14. DEIS II Month Selection (DEIS)

existing terminals. The second problem is the time available to create a graphical report. Time constraints do not permit producing the necessary programming code.

IV. Summary and Recommendations

Summary

The Management Information System developed in conjunction with this thesis was intended to be the first step towards a full implementation as recommended by the research. The most basic functions were incorporated to provide for the immediate usefulness. The results of the implementation at Wright-Patterson AFB proved the system does not provide all of the function necessary for a useful system.

In particular there were three items which restrict the usefulness of the current development. The first and most important weakness was the lack of a way for users to develop customized reports without writing computer code. The structure required by the different types of data made the WANG report utility useless for this task.

The next problem was the lack of a way to determine the current consumption per square foot of the existing base and housing facilities. The original understanding was that these features were handled by the current DEIS II program released from the center.

The final omission was the ability to establish a billing rate to charge reimbursing agencies based on the cost per unit of each of the utilities. The billing was calculated by dividing the cost of the utility by the quantity consumed. The current program ignored the provisions for passing along additional charges as spelled out in AFR 91-5.

These oversights in the basic research made the test at Wright-Patterson unprofitable for the Wright-Patterson personnel. The lack of utility rate calculation excluded the system from being usable for billing reimbursable customers. Likewise, the lack of a method for calculating energy consumption per square foot eliminated energy tracking as a possible use.

This development did not meet the full set of goals desired for a functioning system. However, this collection of computer programs does seem to have promise. The preliminary research which defined this system gave the necessary outline for an energy conservation MIS. This implementation provided the fields for the utility invoices, meter readings, and contract data. This was and is a usable framework for further development.

Even the discovery of weaknesses in the implemented MIS gave information about further development. The three main databases and their data entry programs worked as designed. When used in conjunction with the recommended enhancements a centrally managed system can be developed. The advantage to this approach is that the data gathered will be useful in designing a better system.

With additional work, the system should be ready for a small test here at Wright-Patterson and then a large scale test, including other CONUS bases.

Recommendations

Problem 1. The first problem to tackle is to provide the rate structure as outlined in AFR 91-5. The most practical method would be to produce another database containing the rates for each consolidated bill on a monthly bases.

Problem 2. The next area to consider is to enhance the users ability to produce customized reports at base level. This might mean the acquisition of a relational database program for the VS computer system or conversion to a massive flat file.

Problem 3. Another problem to tackle is to provide the system a method for computing the consumption per square foot value used to track the progress in the energy conservation program.

Problem 4. To enhance the basic use of the system and transition from an MIS to a decision support system, the system needs the ability to determine facility's energy performance over time. This would allow an operator to graph the consumption per square foot over an extended period of time to see if any changes occur.

Problem 5. An additional enhancement would be to provide the comparison between consumption per square foot and the degree days. This could give the ability to determine if the building envelope improvements offer any potential savings.

Appendix: Energy Conservation Officer Duties and Responsibilities Questionnaire

SECTION I. Demographic information to determine if any general characteristics exist among the people preparing the DEIS II Report.

1. Name:

2. Base:

3. Unit and Office Symbol:

4. Autovon Number:

5. What was your Last Degree?

6. How long have you been an Energy Conservation Officer or Utility Officer?

7. Have you received any formal training on Energy Conservation methods?

   a. Yes   b. No

8. Which best describes your duties as an Energy Conservation Officer.

a. It is covered by my job description.

b. It is an additional duty.

SECTION II Specific question relating to the energy conservation program.

9. How many Electric Bills does your base receive?

10. What is the rate structure of these bills?

11. How many Natural Gas Bills does your base receive?

12. How many reports do you produce per month/quarter (choose time period)?

13. What percentage of your work day is used to produce these reports?

14. What percent of your time do you spend per month collecting energy data?

15. What types of data do you use for the energy conservation program?

16. Do you use a computer in the Energy Conservation Program?

a. Yes b. No

17. If you answered yes to question 15, what percentage of the work is done by computer?

18. If you answered yes to question 15, which computer system is used for the energy conservation program?

a. Personal computer c. Other

b. Wang VS computer

19. What percentage of the time you spend on the Energy Program contributes to cost savings?

SECTION III Unstructured questions to allow you to provide additional information about your job.

20. Please list any other actions you take in performing your duty as an Energy Conservation Officer?

21. Please make any additional comments you have here?

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Vita

First Lieutenant Benjamin H. Cutler [redacted]. He graduated from high school in Kalispell, Montana in 1974. After serving in the United States Air Force for nine years, he was selected for the Airman's Education and Commissioning program. He completed this program with a bachelors of science degree in electrical engineering from the University of Hawaii on 3 July 1986. At the completion of Officers Training School, he was assigned to the 3498th Civil Engineering Squadron at Goodfellow AFB, Texas. During the two and a half years at Goodfellow AFB, Lieutenant Cutler held the primary job of electrical engineer in the design branch. In-additon to being a design engineer, he served as the Energy Conservation Officer for Goodfellow AFB from January 1988 until March 1989. In May of 1989 Lieutenant Cutler entered the Graduate Engineering Management program at the Air Force Institute of Technology's School of Systems and Logistics.

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13. ABSTRACT *(Maximum 200 words)*

This study investigated the possibility of creating an energy accounting system based on currently identified objectives. The initial focus was to determine if such a system would be useful. By reviewing literature, it became obvious that the conditions which lead to the energy crises in the 1970's still exist. In fact, most of the indicators are that the United States is more dependent upon foreign oil than at any time in the past. Couple this finding with the failure to meet the 1985 energy reduction goal of 20%, and it is obvious that something needs to be done. Adding to the problem is escalating pressure to trim the federal budget. The greatest pressure is on the Department of Defense. Thus, there is a need to improve the methods used to determine how to decrease facility energy consumption. The findings were that any new system needs to decrease the time required to prepare reports, allow the flexibility to customize reports, and provide a method for upward reporting of contract data. The result of this study showed that it was possible to create such a system, but given the tools currently available not all of the objectives were obtainable.

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