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CONSERVATION:

ENERGY MANAGEMENT BY DESIGN

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CONF-790346--

OPENING REMARKS

DR. GEORGE W. RHODES

The BDM Corporation
Conference Chairman

While sequestered with our colleagues, it is incumbent upon us to develop specific approaches to the implementation of energy conserving programs. For many, this period represents the first opportunity to hear and discuss concepts from the various sectors represented at this meeting.

Our objective should be to outline the business and political actions which we can effect in the near term to help alleviate the most significant problem ever faced by our nation.

Our Government is searching for rational solutions, but by taking a lead role we can make it happen faster, cheaper, without additional regulations, and perform a service for both ourselves and our country.

This document serves as a record of the formal presentations. However, the hallways and informal gatherings are the real forums for the development of specific actions. Let us use our time well.

ENERGY MANAGEMENT BENEFITS
THROUGH THE CONSUMER/UTILITY INTERFACE

By
Dan Peck, Director of Load Management
Public Service Company of New Mexico

and
Joe Schilling, Supervisor of Load Research
Arizona Public Service Company

First of all, we would like to thank you for this opportunity to provide the utilities' perspective in the energy conservation/energy management area. Too often, we all tend to take a myopic perspective when developing and implementing programs, examining only those considerations pertinent to our particular interests. This often leads to results contrary to those expected. To give you a better idea of how your programs might impact the utility, I am going to discuss some basics of utility operations. This will lay a foundation to ensure what is said later can be kept in proper perspective.

First, we need to examine the traditional customer/utility relationship (Exhibit 1). This simplistic depiction of the relationship addresses the major communication channels from the customer to the utility and from the utility to the customer. Obviously, considerably more communication takes place, but price signals sent by the utility to the consumer and consumption profiles sent by the consumer to the utility are paramount. Price signals sent to consumers significantly affect how and how much electricity will be purchased. Consumption profiles sent by the consumer dictate the generation mix and operational characteristics of the utility, hence the cost of providing electricity.

Before examining how this works, it must be emphasized that utilities across the nation, and even neighboring utilities, are designed differently. This is simply because they receive different messages (consumption profiles) from their customers. For example, this is Public Service Company of New Mexico's (PNM's) average system profile during the summer of 1978 (Exhibit 2). Also included in this exhibit is Arizona Public Service Company's (APS's) average system profile during the summer of 1978. You can see that the system profiles are quite similar in shape. But, referring to the winter average-day system profiles of PNM and APS, it is easy to see that APS and PNM differ significantly with respect to summer/winter demand relationships. PNM's winter system peak is about 92 percent of its summer peak while APS' winter system peak is only 68 percent of its summer system peak. Because of this difference, the mix of generation units employed to meet customer requirements differs between these two neighboring utilities. In designing the most cost-effective generation mix to meet customer requirements, there are trade-offs between first costs or fixed costs, and operating costs or variable costs. Exhibit 3 is a profile of electricity requirements on a typical summer day and the categories of generating units employed to meet those requirements. These categories are base, intermediate, and peak load units.

"Base-load units" are generally high capital cost, high-efficiency units designed to operate continuously at or near their maximum capacities; these units are generally coal-, nuclear-, or heavy oil-fired.

"Intermediate-load (also referred to as load following) units" are generally lower-efficiency units--often older units originally installed for base-load operation--which typically operate with some overnight shutdown; these units are usually coal- or oil-fired.

"Peaking units" are low capital cost, typically less-efficient units, which are intended to operate during (relatively short) periods of peak (or highest) system load, or during emergencies; these units are either light oil- or gas-fired.

As this exhibit demonstrates, base units are operated continuously, peaking units are operated only a few hours a day, and intermediate units operate somewhere in between. The reason for this mode of operation, referred to as "economic dispatch," is to keep the variable cost of providing electricity as low as possible. For example, this exhibit (Exhibit 4) shows the planned generation capacity by type and percentage of generation for PNM in 1988. Also shown is the forecasted amount of energy to be produced by generation type for 1988. These figures are not official because PNM's generation expansion plan has recently been revised. As can be seen, PNM's forecasted generation capacity of about 2,400 MW was to be divided among 17 percent nuclear generation, 60 percent coal, 13 percent pumped hydro, and 10 percent oil- and/or natural gas-fired generation. PNM's forecasted electricity generation was to be made up of 26 percent from nuclear generating units, 64 percent coal, 7 percent pumped hydro, and 3 percent from oil and/or natural gas generating units. The reason for this disparity between generation capacity mix and energy mix is straightforward. The forecasted variable cost associated with producing a kilowatt-hour from a nuclear-fired generation unit is approximately one-fifth of the cost of producing a kilowatt-hour from an oil-fired generation unit.

PNM must have the generation capacity to meet customer requirements. On those days where peak and near-peak energy is being demanded, all of PNM's generation units will be running. During periods where less-than-peak energy requirements are being experienced, the higher variable cost generation units will be shutdown, with the energy requirements being met by the lower variable cost units. Although this does not decrease fixed costs, it does keep variable costs at a minimum. Also, it should be noted that the lower variable cost units employ resources in greater abundance, such as coal and nuclear, than the higher variable cost units which use relatively scarce natural resources, such as oil and natural gas.

Now that we have covered variable costs of producing electricity, we need to examine the fixed cost component. Something that has created confusion in the past is the concept of, 'use less electricity and pay more per kilowatt-hour.' This unpleasant situation is due to the fact that, between variable and fixed costs, the larger component of the electric bill is associated with fixed costs. Electric utilities, by the nature of their business, are capital intensive. A typical electric company must invest five dollars of capital for every dollar of power it produces and sells annually. By way of comparison, General Motors needs only about 55 cents of capital per dollar of sales.

I think the best way to explain how this works is with a highly simplified example involving fixed and variable costs. Let us assume a small utility with only one customer. Over the years, the utility president has learned that he can expect his customer will have a maximum demand for electricity of six kilowatt-hours per hour (a six-kilowatt demand) and that he has purchased the facilities necessary to meet that demand. Prior to the customer's decision to conserve energy, his weekly consumption habits were as shown in this example (Exhibit 5).

For 18 hours a day, the customer would consume electricity at a rate of 1 kilowatt-hour per hour; and for the remaining 6 hours of the day, when it got hot outside and he would turn on his air conditioner, he would consume at a rate of 6 kilowatts per hour. Each week this amounted to a consumption of 378 kilowatts. Now, on the utility side of things, it cost the president, including his profit, 2 cents per kilowatt in variable costs and $2 per kilowatt per week of generation facilities in fixed costs. This resulted in a bill to the consumer of $19.56, which amounted to a cost per kilowatt of about 5.2 cents. Everyone was happy.

Then, the customer decided to conserve energy, at least to a point. He decided that he would conserve energy by not using his air conditioner all week long, except for Wednesday afternoon when his friends came over to play poker. Resulting from this method of energy conservation, his consumption profile looked like this (Exhibit 6). He was consuming electricity at a rate of 1 kilowatt per hour for 162 hours a week, and at 6 kilowatt-hours per hour for 6 hours per week, for a total usage of 198 kilowatt-hours per week. He conserved 180 kilowatt-hours per week, a 48 percent reduction in consumption. His bill (actual cost of service) only decreased from $19.56 to $15.96, or 18 percent, but the cost per kilowatt-hour increased 56 percent, from 5.2 cents to 8.1 cents. Then nobody was happy. The customer was experiencing some inconvenience, did not believe he was being adequately compensated for this inconvenience, and he thought the utility president was making windfall profits off of him. The president, on the other hand, was unhappy because, while his profits did not increase, his job had become an unpleasant task and he was no longer invited to the poker games.

I hope this amusing portrayal of a real and unpleasant situation for consumers and utility employees has clearly demonstrated the problem. Fixed costs, which are often overlooked, are an extremely important component in the cost of producing electricity. It is pretty straightforward to see how this analogy could be carried forward to the potential impacts solar heating could have on a winter-peaking utility.

Let us go a step further--the situation could be worse. What would have happened if the consumer decided not to use his air conditioner at all? From the customer's perspective, he has the right to believe that, since his maximum demand is only one kilowatt, he should be charged for only one kilowatt. From the utility president's perspective, he has the right to believe that, because the customer's historical consumption habits dictated that the utility have a six-kilowatt generator--not a one-kilowatt generator--even though the customer now only wants one kilowatt of generation, the customer should pay for the cost of having the six-kilowatt generating unit until the president can make other arrangements, assuming he can. What would happen if the customer decided to install an energy-efficient air conditioning system that would not only have equivalent cooling ability for less kilowatt-hours, but would also reduce the demand it placed on the utility's system? Again, the only incentives that could be provided to the customer to install such equipment are in the form of variable costs until the utility can rearrange or sell part of its generation capacity.

This is the real world. Traditionally, the customer/utility relationship has been that of the utility providing the customer with as much electricity as he wanted, when he wanted it. The relationship used to be justified because of the relatively low cost of producing electricity. Alternatives to this historical relationship were hard to justify from either a cost or a convenience perspective. Times have changed and so should the relationship, and it is changing.

The change is going to be slow. While utilities are factoring energy conservation/management into their load growth forecasts and resultant planned generation schemes, extremely long lead times are associated with capital investments, such as a generation unit. Large base load generation may take from 8 to 12 years to put on line after the decision to build it has been made. In terms of the first major effort toward energy conservation which resulted from the OPEC oil embargo, generation units started just prior to the oil embargo were not expected to come on line for several years from today.

Obviously, utilities have deferred on-line dates by slowing construction efforts where possible but, with these long lead times and long life expectancies of generation units, usually 30 years, it takes a significant amount of time to make adjustments. The old customer/utility relationship will be hard to change and even harder to plan for. Will the customer readily adopt or modify his consumption habits in response to such things as time-of-day price signals? Will he allow the utility to control his appliances? Will the customer install energy storage devices? There are many unknowns.

Hopefully, these changes in the relationship will be well planned. For example, utilities are often accused of attempting to stifle the adoption of solar-augmented space heating and water heating systems. In one respect, they are right; on the other hand, they are not properly planning for their and the customers' future. At PNM, we feel that customer adoption of solar systems could greatly benefit the customers adopting solar, the rest of our customers, and our Company, if properly planned. But, the converse could be true if the interface between the solar system and the utility system is not properly planned for by both the customer and the utility.

It is easy to compare the previous example of the customer who conserved energy by using his air conditioner only one day a week with that of the typical solar system being built today. While conserving conventional energy resources on the average day, the way many solar systems are being designed, they do not defer the need for generation capacity fixed costs for use during periods of inclement weather conditions (Exhibit 7). But why should they be designed otherwise because, in most instances, the utility is not providing the price incentives to have the system built any other way. What happens, given today's typically nontime-differentiated rate design, is that the costs of providing the solar customer are not being recouped through the rates, which results in an average cost per kilowatt-hour increase to all customers. Obviously, this is not an attractive situation, especially since it tends to have the lower-income customer subsidize the higher-income customer's electric bill because, presently, only the more affluent can afford solar-augmented systems.

If, through proper rate design, the utility can provide price incentives to promote the adoption of solar systems which appreciate their interface with the utility system, everyone will benefit. Given proper price incentives, solar systems can employ the storage medium inherent in good solar design as an energy management facility for storing off-peak energy, and use the energy management capabilities to interface with the utility system in the most cost-effective manner (Exhibit 8). The incentives should easily cover the incremental costs associated with the additional storage capability. In effect, the solar home owner would be able to take advantage of variable and fixed cost reductions in his electric bill.

This is just one of many scenarios that can be easily imagined. As I have demonstrated, energy conservation by itself can be counterproductive in many respects. It is through well-conceived programs that achieve harmony between energy conservation and energy management, while appreciating the dynamic interaction between the consumer and the utility, that optimal rewards will be obtained.

The discussion, thus far, has been in general terms. The true nature of costs from a utility standpoint have been identified, along with the important conceptual differences between conservation and energy management. We now move to the more specific area of actual research activities presently being conducted.

The present procedure follows what might be termed a "mutually exclusive" approach (Exhibit 9). The hallmark of the approach is the fact that it is tailored to existing equipment or environments. Additionally, although there are literally hundreds of tests under way, they all fall into one of three major categories. The first are rates oriented--the most visible of these types being time-of-day experiments. Secondly, those that utilize a control device, either at the customer location or directly by the utility through a radio signal, power line, telephone, or some such medium. Finally, there are those activities purely aimed at end-use application, examples being solar, storage systems, and cogeneration.

In terms of hands-on experience in these three major categories of present research activities, APS and PNM have an excellent track record. Indeed, between them, most of the major research targets have been tested. As an illustration of their experience, each company will provide test description and analysis highlights from four recent experiments.

RESIDENTIAL TIME-OF-DAY EXPERIMENT

APS began this rates-oriented experiment in 1975 and has continued it up to the present. Approximately 200 customers were selected at random and their consumption monitored for three time periods, without special rates being applied, during 1975. This procedure established a "base" consumption to which reaction under actual rates could be compared. During this period and 1976, the first year, where time-oriented rates were applied, this test was done in conjunction with DOE (nee FEA). Additionally, two University of Arizona economists were contracted for aid in general test and rates formatting, as well as analysis. As might be expected, there were some disagreements as to what the final results indicated, with the FEA utilizing some rather exotic statistical methods to establish relationships between energy consumption patterns and price, while the economists concluded the results were statistically inconclusive. In-house analysis tended to support the conclusion of the economists and Exhibit 10 illustrates this. This chart shows a comparison of the percent change in consumption achieved during the peak hours (2 p.m. to 5 p.m.) versus the ratio of peak to off-peak price for both 1975 to 1977, and 1975 to 1978. Again, this represents a rather straightforward attempt at quantifying pricing impacts, and its illustrative worth more than makes up for its lack of sophistication. Beyond this energy-to-price relationship, indeed inherent in cost reductive capabilities of any timed energy rate, is the assumption that demands will track energy responses. As an addition to the basic test, the company utilized special metering on approximately 30 of the selected customers to verify this assumption. Exhibit 11 shows the average day (24-hour) profile for 27 of these customers and a matching set of customers on a nontime-related standard rate. Again, as in all cases, the consumption during the peak period was down for the time-of-use customers. The question of demand, however, generates a different response. Exhibit 12 shows these same groups of customers and their profile for one particular day in July--the day of the APS system peak. The demand at the time of system peak and the entire three-hour peak period is identical. So, on a monthly basis, the customers' bills and the corresponding utility revenue would go down, but a corresponding reduction in costs through reduced peak demands never materialized. Although the sample sizes are small and the basic kilowatt-hour results can be established as price sensitive utilizing sophisticated statistical procedures, the planning of reduced plant requirements in the future, on the basis of these test results extrapolated to full rate implementation, appears to have no legitimate basis.

SUPERVISORY LOAD CONTROL EXPERIMENT

APS conducted this test over two consecutive summers. It involved the use of a radio signal to control the air conditioning compressors at approximately 110 residences. These residences were selected from a total of 150 in one subdivision and were, therefore, extremely homogeneous. The experiment was structured to answer the following questions:

1. Equipment performance characteristics
2. Customer reaction
3. Load reaction

Exhibit 13 illustrates graphically the results of this load controlling as measured by a recording meter at the subdivision service dip pole. Two items are of interest. First, the amount of kilowatt reduction and, secondly, the lack of forced coincidence when the load returned. This second fact was of prime interest, since the possibility of creating a new and larger peak was of great concern.

The results of this study are presently being finalized, but one question remains unanswered. That is the quantification of possible market penetration for this type of system. Are customers' monetary and energy concerns at a level where they would relinquish control of major appliances to anyone? Market education and attitude survey efforts may provide part of the answer, and these will be conducted.

AIR CONDITIONING WASTE HEAT FOR HOT WATER

APS began experimenting with this procedure over three years ago. The system basically utilizes the heat generated from the air conditioning compressor to heat water. The water line is plumbed to the air conditioner and returned to the hot water tank. Exhibit 14 illustrates the impact of this procedure in terms of reduced water heater requirements for a calendar month at a residence. This research effort resulted in APS' active participation in promoting this device for both residential and commercial application--not on the basis of the kilowatt-hour reduction, for that is merely a customer gain and corporate revenue loss, but due to the removal of the water heater's demand during time of system peak.

DEMAND REDUCTION PROGRAM

The target group for this research, which also resulted in an actual program, was large commercial and industrial customers who had special metering installed for our basic cost of service research. The customer's profile was analyzed on the day of his maximum demand, on an average weekday basis, and both were compared with the demand level coincident with the APS system peak. Exhibit 15 illustrates this type of analysis. The customer was then contacted with this illustration and asked for his aid in reducing both his bill and our peak. Upon agreement, an "energy diary" was monitored by the customer for one month, and comparable printouts produced enabled the identification of processes or activities that caused his peak. The customer is then encouraged to purchase controller equipment to limit the demand level, which benefits both the customer and the company.

Now, a review of four illustrative research activities at PNM will follow.

SOLAR WATER HEATING EXPERIMENT

In 1978, PNM had ten solar water heating systems installed on residential structures. Another 20 systems will be installed in 1979. The 30 systems will be comprised of several different types of systems, such as liquid collectors with a dual-purpose tank, with a preheat tank, and with a regular water heater; air collectors with different storage set-up schemes; and so forth. All of the systems to be installed are available in the marketplace. Some of the more important goals of this test are: to discover what major installation problems could be expected and to develop procedures to overcome these problems, to discover the customer cost/benefit potentials of the various systems, to determine utility cost of service information on the systems, and to gather information for load forecasting purposes.

Many studies of solar water heating have only examined variable cost components as discussed earlier. It is possible that the systems, which reduce electricity consumption the greatest, may place the largest demand on the utility system, thus not reducing the fixed cost component of producing electricity. We believe it is shortsighted to look only at the variable component of the total cost picture. PNM will be in a position to examine total costs and provide that information and appropriate incentives to our customers to promote (demote) those preferred systems that appreciate (do not appreciate) their impact on the utility system.

Although not enough data has been collected to make detailed analyses, Exhibit 16 contains average-day load profiles for typical electric and solar-augmented electric water heating systems. This exhibit is based on a small sample size and should be treated accordingly.

PNM/AMREP-HUD CYCLE 3

PNM, in cooperation with a local builder, AMREP, is building 25 solar/load managed homes. The incremental costs to the solar components are being funded via a HUD Cycle 3 grant. This is a schematic of the solar systems (Exhibit 17).

A unique feature of the solar system is the controller. This controller is capable of making decisions based on sensor information and time of day. For example, if a sensor located in the rock bed storage bin detects a temperature less than that required to supply the home's needs through one full day of inclement weather, and the time is during the off-peak period, then the controller will allow the auxiliary strip heater to charge the rock bed storage bin. This is a significant load management feature of the system in that it inhibits on-peak auxiliary usage and allows total off-peak utilization.

These homes will be fully monitored to determine, among other things, efficiency of the solar and load management systems, cost/benefit, and cost to serve.

EPRI/ILC-SHAC RESIDENTIAL PROJECT

PNM is hosting the construction, now complete, of five SHAC demonstration homes as part of an Electric Power Research Institute Research Project (RP 549), Individual Load Center-Solar Heating and Cooling Residential Project. The objectives completed as part of the initial phase of project work were to:

1. Develop system and component requirements and provide preliminary design for preferred SHAC residential systems for two geographical regions of the U.S. (Albuquerque, New Mexico, and Wading River, New York).

2. Provide system designs and integrate them into five houses to be located at each site.

3. Develop a consistent instrumentation, test, and evaluation plan for the SHAC experiments.

4. Develop plans for the following phases of implementation and evaluation of the experimental project.

In parallel, development with the early phases of RP 549 was another EPRI project, RP 926. This project developed a flexible computer program for determining preferred solar-assisted heating and cooling configurations for residences in specific utility service areas. Based on input data for rates and cost of energy supplied by local utilities, analysis of various SHAC options (including customer storage, super insulation, etc.) can be assessed for their potential to economically satisfy the customer's heating, cooling, and domestic hot water requirements.

PASSIVE SOLAR HOME PROJECTS

This project is similar to the active solar home projects in that the home will be designed to use only off-peak energy for its back-up heating requirements, no matter when they may occur. State of the art solar passive design dictates that the structure must employ significant amounts of mass to avoid the large temperature swings experienced in most of the earlier designs. We believe there is no reason why this large thermal mass cannot be used to store off-peak energy, and that the incremental costs of doing so will be more than offset by reduced utility bills passed on to the consumer.

There are two major shortcomings associated with the tests monitored and, indeed, with most tests under the present "mutually exclusive" approach. It should be remembered that these observations do not come from "outsiders," but rather from two utilities which have been and continue to be at the forefront of customer-oriented research.

The first problems are strictly related to the "research mentality" or procedure. Exhibit 18 lists major symptoms of this type of problem. The rates utilized usually bear little resemblance to any that might be termed cost justified. Additionally, they are often accompanied by outright customer monetary inducements. Finally, and often as a net result of the rate situation, the test customers can usually be termed as researchers or game players. The utilization of results from this type of test bed to anticipate the reaction of a whole customer class is extremely dangerous.

The second major category of shortcomings deals specifically with the present "mutually exclusive" approach. As Exhibit 19 illustrates, each test stands alone. We catalog the net result of each test, conducted in a vacuum, and compare them. But how is a total energy management procedure established? Are the results additive? Will half the demand reduction program's benefit be taken by waste heat recovery or solar? This leads to a second problem; what relationship do studies conducted in a research vacuum really have to "real life"? Have we indeed measured the maximum? Cannot the total reduction be possibly greater than the parts? Given the vacuum nature of the experiments, the research-oriented nature of the customer, and the short duration of even unrealistic rates, the application of results for system planning are almost impossible. The problem is coordination, and the result is confusion--for the customer, the utility, and everyone else involved in the energy field today.

As we see it, the solution lies in systematic planning. Exhibit 20 illustrates what might be termed a system approach for both present research and future implementation. It basically involves putting one face to the public, gauging reaction, and producing needed equipment, standards, and rates. Overlaying this approach, or even coming between the customer and established procedures, would be the various governmental and regulatory agencies. Commitments are needed. Exhibit 21 lists the minimal commitments needed by category. State and local governments must "bless" the proceedings and attempt to keep them out of the political arena. The timing and cost-related rate issues will automatically necessitate the active support of local regulatory agencies. Finally, most of you in related industry and we in the utility industry, as well as the customer himself, must mutually commit ourselves to the determination of the best procedure for true energy management--not necessarily the one we presently support.

What are the targets of this coordinated approach to load management? Exhibit 22 lists some of the obvious goals. First is the addition of customers and industry allies in the quest for true energy management. This involvement will allow the limiting of research to feasible paths. A coordinated approach will yield the identification of true problems or problem categories. This same approach will literally force various governmental and regulatory agencies to commit to long-term strategies and remove some of the political/emotional obstacles. Hopefully, this systematic procedure will reduce the number of families relegated to living in "caves" by limiting life-style impacts. It will also serve to reduce "false start" research and full-scale implementation plans that could be expensive. At the same time, this strategy would enable true incremental cost/benefit calculations to be conducted on various components of a full-scale load management effort. Finally, and possibly most important from a utility standpoint, it would spare us all from what might be termed the "savior" syndrome. No problem or question has as easy a solution as many would have us believe.

Let us move to the bottom line as shown on Exhibit 23. Utilities work in a planning mode of 20 to 30 years in length. Even after a decision for capital-intensive plant expansion is made, it can take from 8 to 12 years for construction. Both energy management and a systematic approach to energy management must recognize that any reduction in future plant addition <u>must</u> be firm. If, after three years, the original commitment is lost or found to be overestimated, it will still take the same time to build a plant; so the question becomes, "How do we handle the last three years in terms of future shortages?"

The conclusion to all this is quite simple: present research procedures and recommended individual methodologies are not working. The data gathered is not bad, in itself, nor are most of the recommended methods; but the need exists to determine their interaction and the net benefits of each within the energy management whole.

What is needed, as a possible first step, is the recognition of the geographic and economic individualism of utility systems--their construction standards, equipment characteristics, and how their relation/impact vary from utility to utility. Secondly, a coordinated review of energy management options in all of these categories is needed and a recommended, long-term test procedure plan must be established. This task is a major undertaking and, given the diversity of interests, could probably best be accomplished under federal auspices. This would also illustrate the needed commitment at the federal level and initiate the needed impetus at the local and regulatory level. Finally, support from the various vendors, manufacturers, engineers, architects, utility people, and anyone else with interest in energy management must be coordinated. The results to date have not only frustrated us but, more importantly, confused the customers. To gain their confidence once more, we need a base of diversified support with a comprehensive plan of action.

The road ahead is rough and the lack of simple solutions is frustrating, but we believe the problem has been diagnosed and, given the proper support, the long-term prognosis is for a solution to the energy management questions.

CONSUMER/UTILITY COMMUNICATION CHANNELS

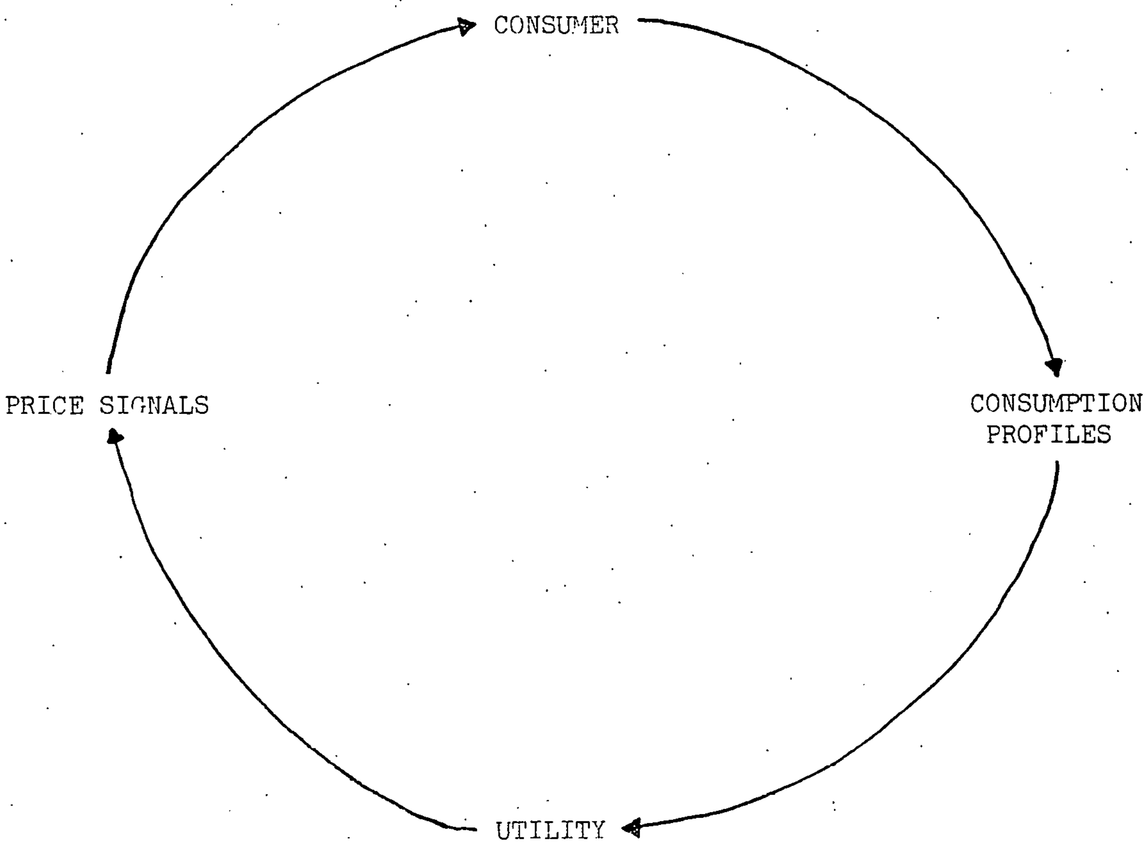


EXHIBIT 1

TYPICAL WEEKDAY PROFILES

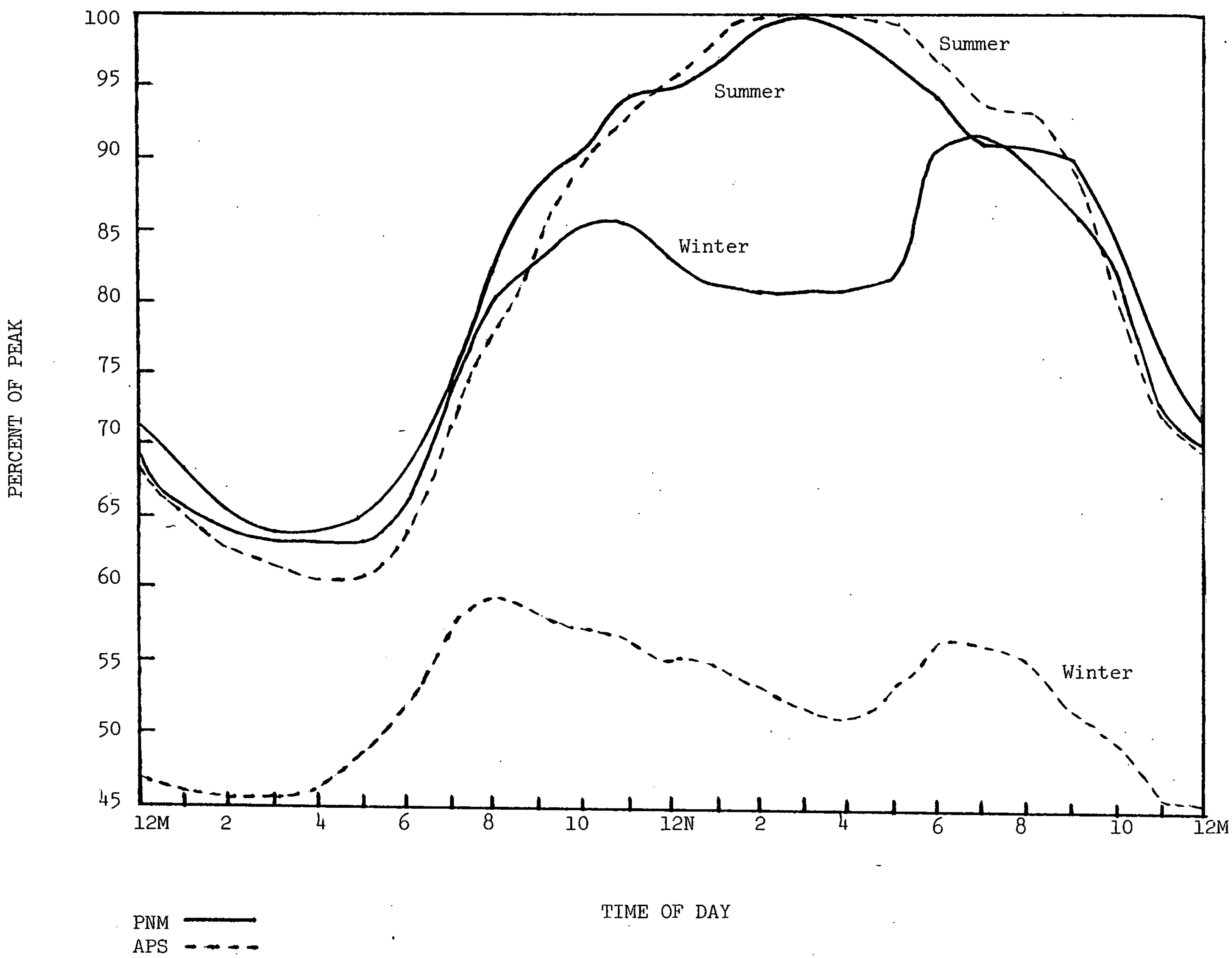


EXHIBIT 2

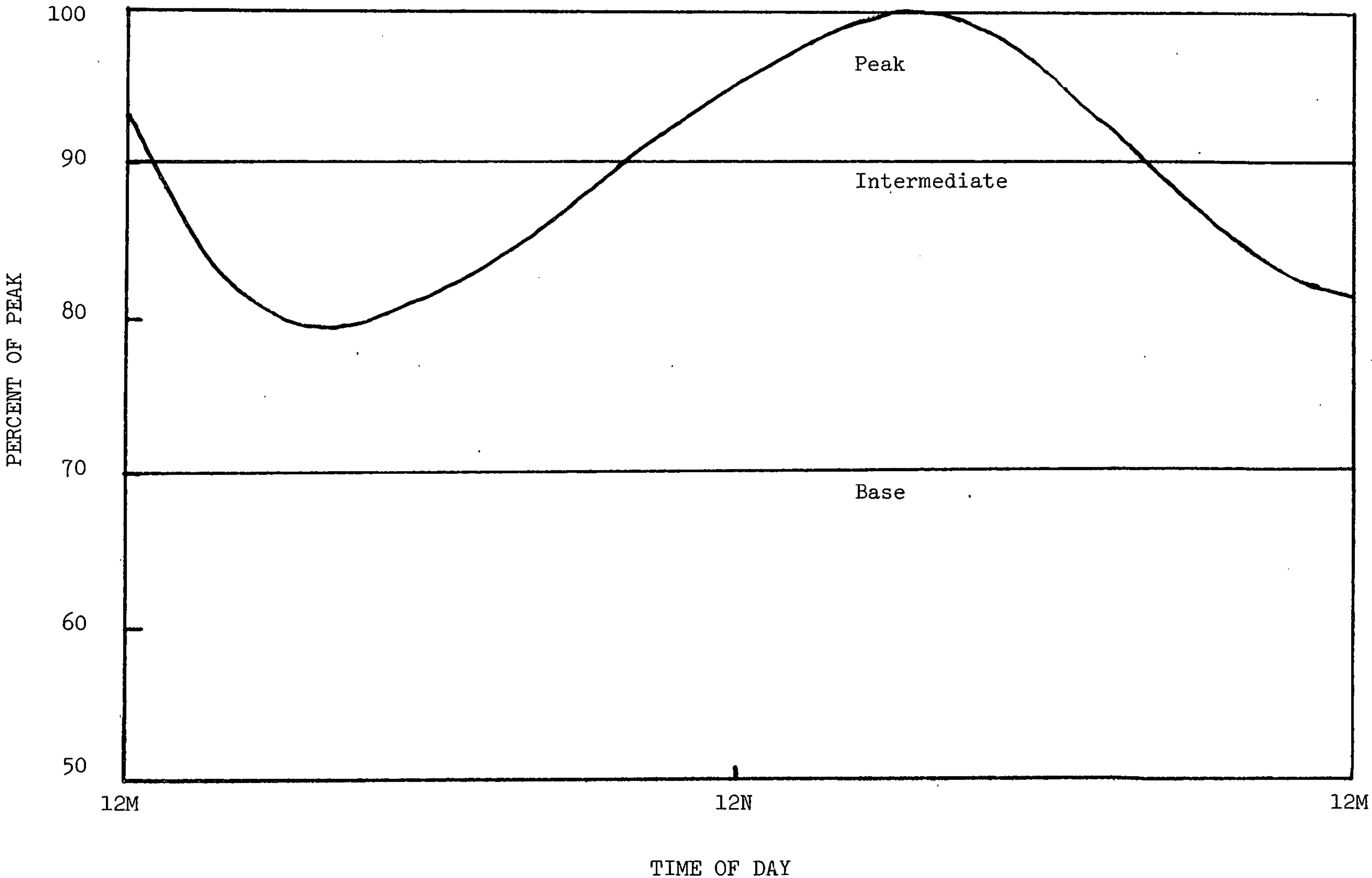
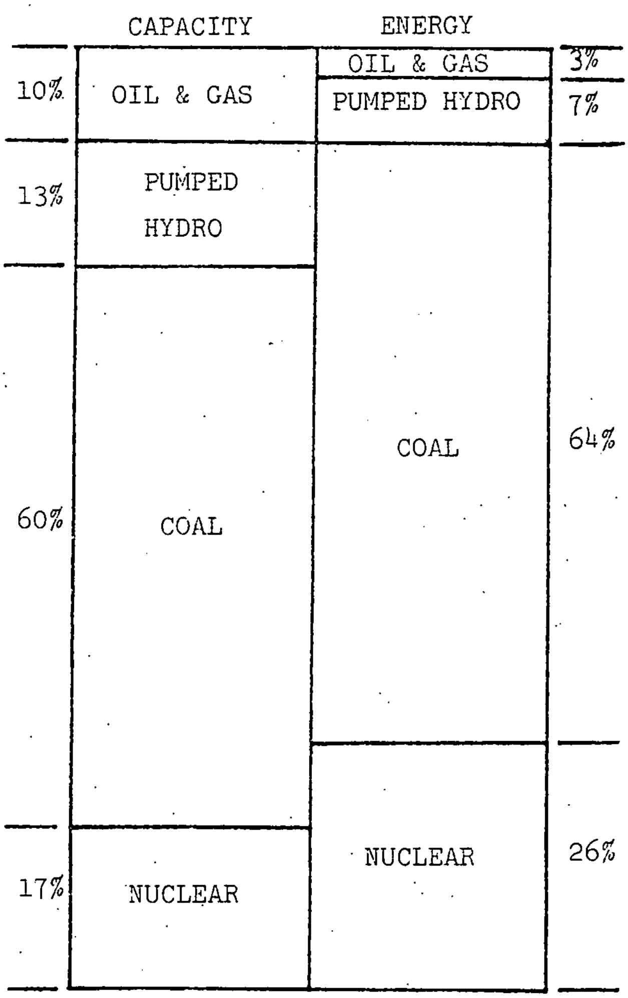

100
90
80
70
60
50
PERCENT OF PEAK
Peak
Intermediate
Base
12M
12N
12M
TIME OF DAY

EXHIBIT 3

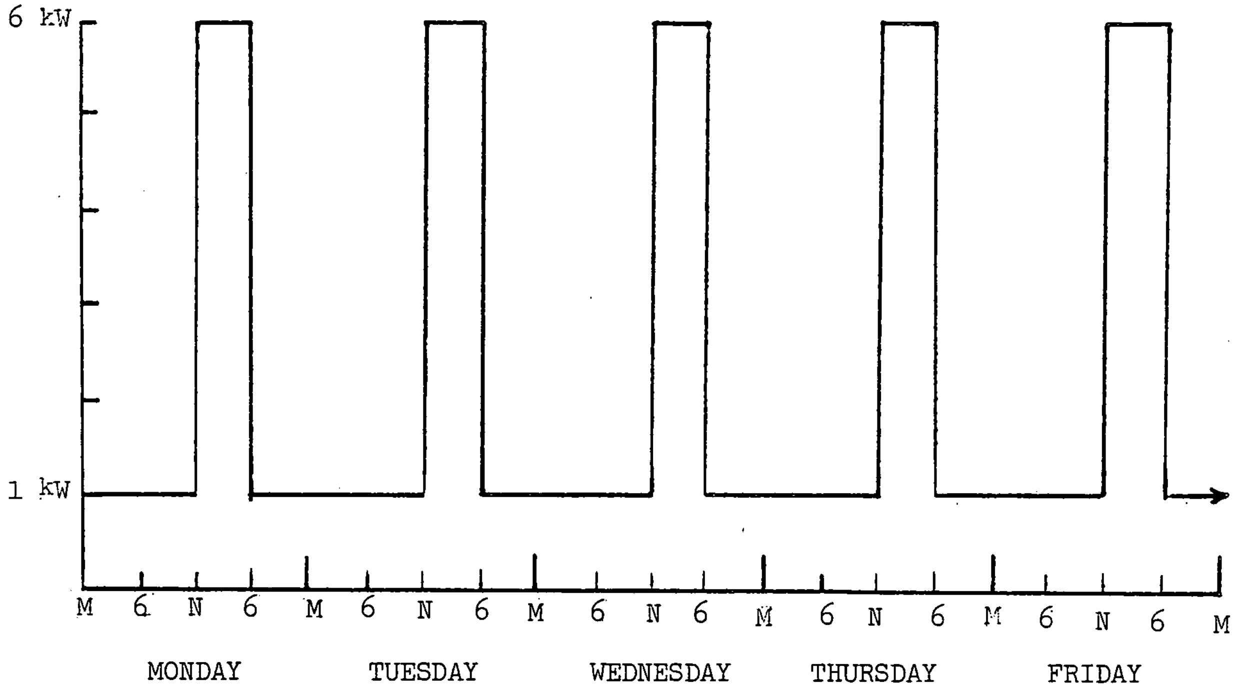
PNM'S FORECASTED GENERATION CAPACITY AND ENERGY MIX FOR 1988*



* NOT OFFICIAL; HAS BEEN REVISED

EXHIBIT 4

EXAMPLE 1



CONSUMPTION

1 kW @ 18 HRS/DAY FOR 7 DAYS	=	126 kWh
6 kW @ 6 HRS/DAY FOR 7 DAYS	=	252 kWh
		378 kWh/WEEK

COST OF SERVICE

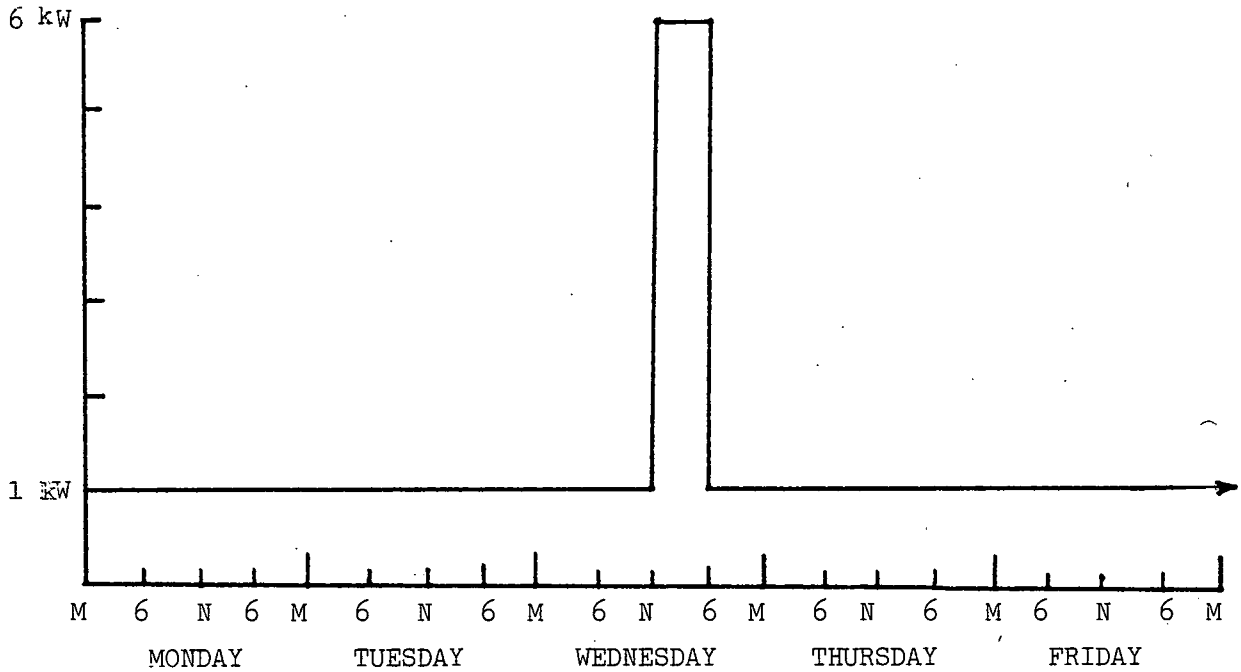
VARIABLE	=	2¢/kWh @ 378 kWh	=	$ 7.56
FIXED	=	$2.00/kW @ 6 kW	=	12.00
				$19.56

COST PER kWh

$$\frac{\$19.56}{378\text{ kWh}} = 5.2¢/\text{kWh}$$

EXHIBIT 5

EXAMPLE 2



CONSUMPTION

1 kW @ 162 HRS/WEEK = 162 kWh

6 kW @ 6 HRS/WEEK = 36 kWh

198 kWh/WEEK

COST OF SERVICE

VARIABLE = 2 ¢/kWh @ 198 HRS = \$3.96

FIXED = 2 \$/kW @ 6 kW = 12.00

\$15.96

COST PER kWh

$$\frac{\$15.96}{198\ \text{kWh}} = 8.1\ ¢/\text{kWh}$$

EXHIBIT 6

NON-PREFERRED SOLAR SYSTEM PROFILE
IN RELATION TO UTILITY PROFILE

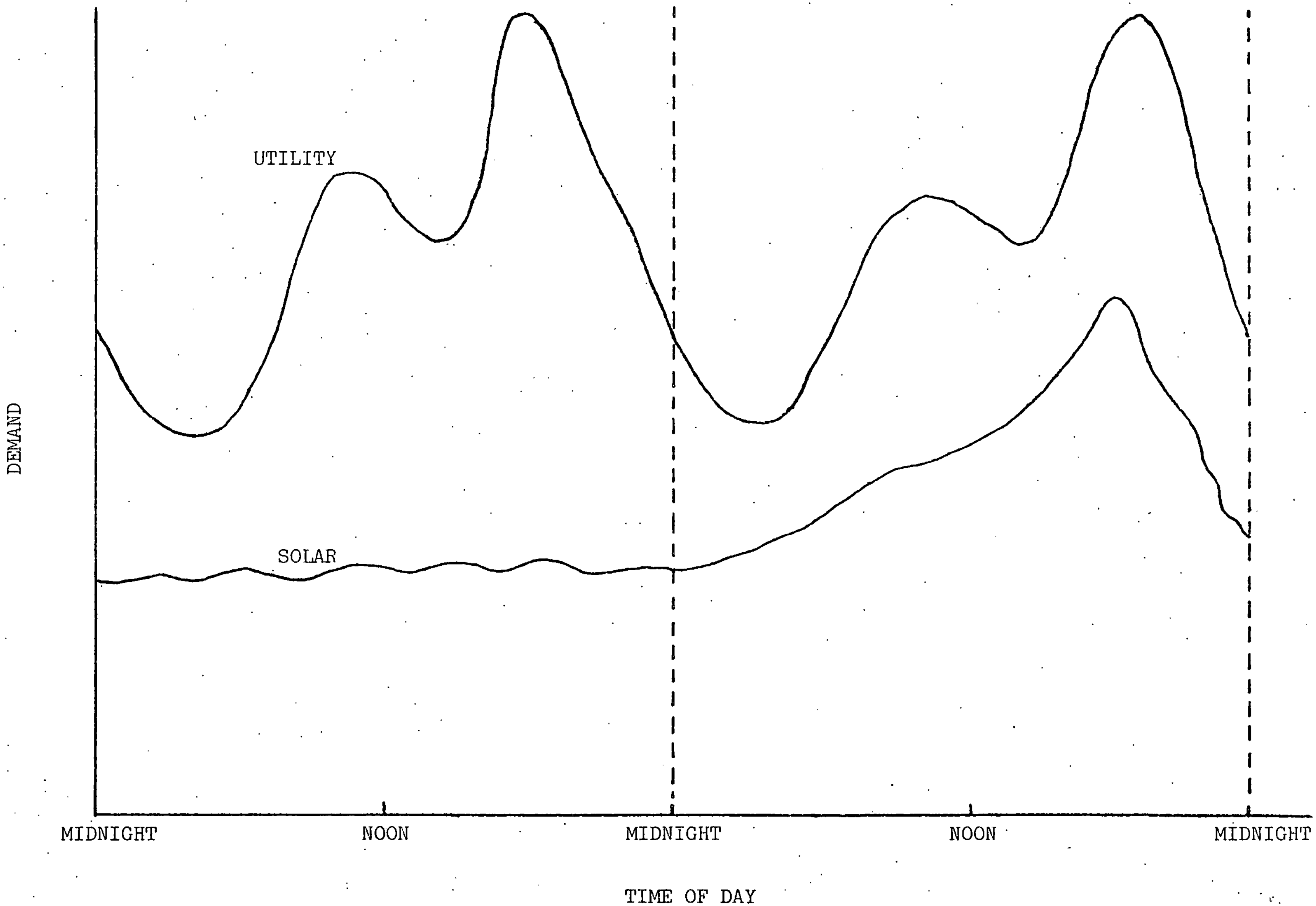


EXHIBIT 7

PREFERRED SOLAR SYSTEM PROFILE
IN RELATION TO UTILITY PROFILE

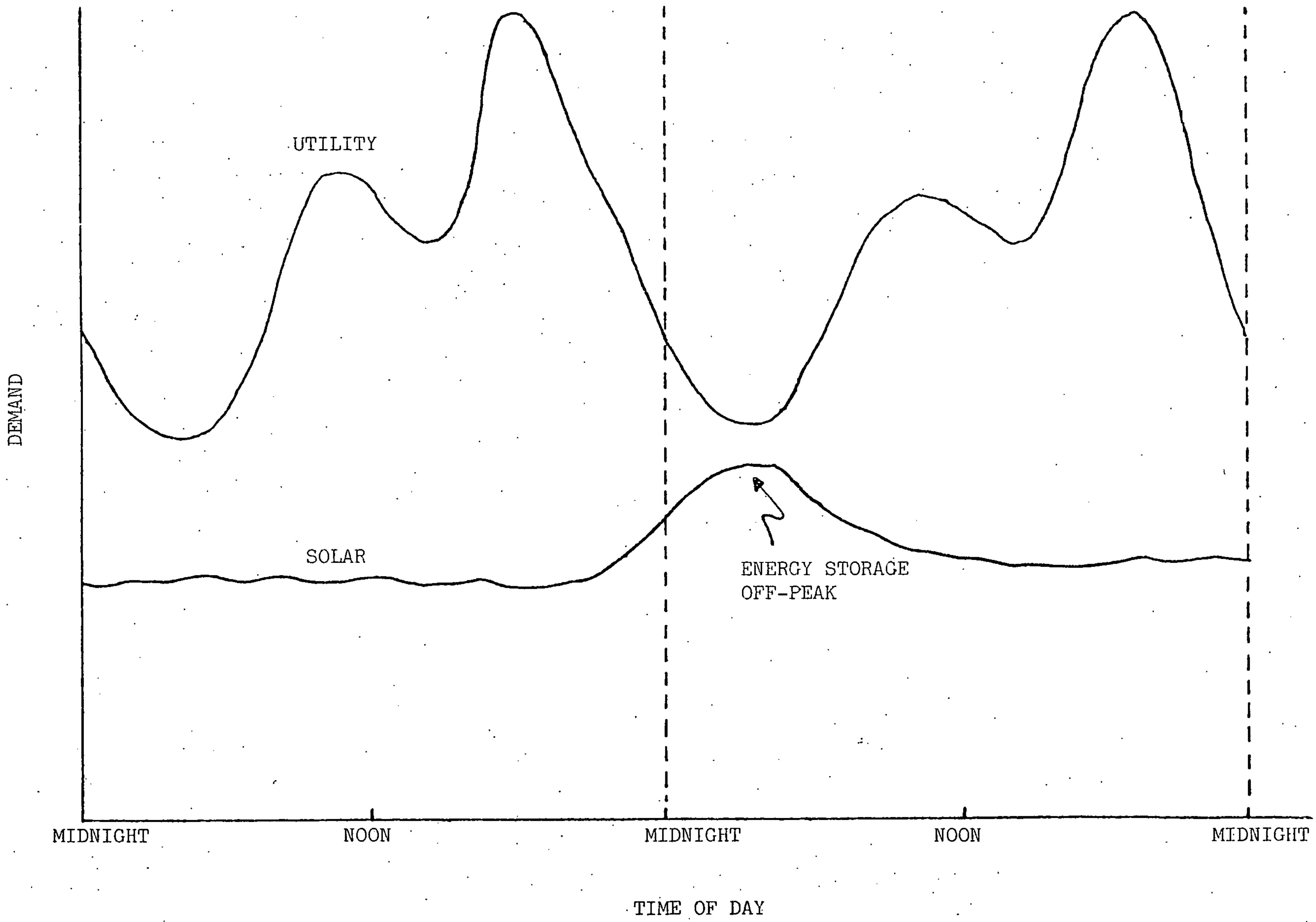


EXHIBIT 8

MUTUALLY EXCLUSIVE APPROACH

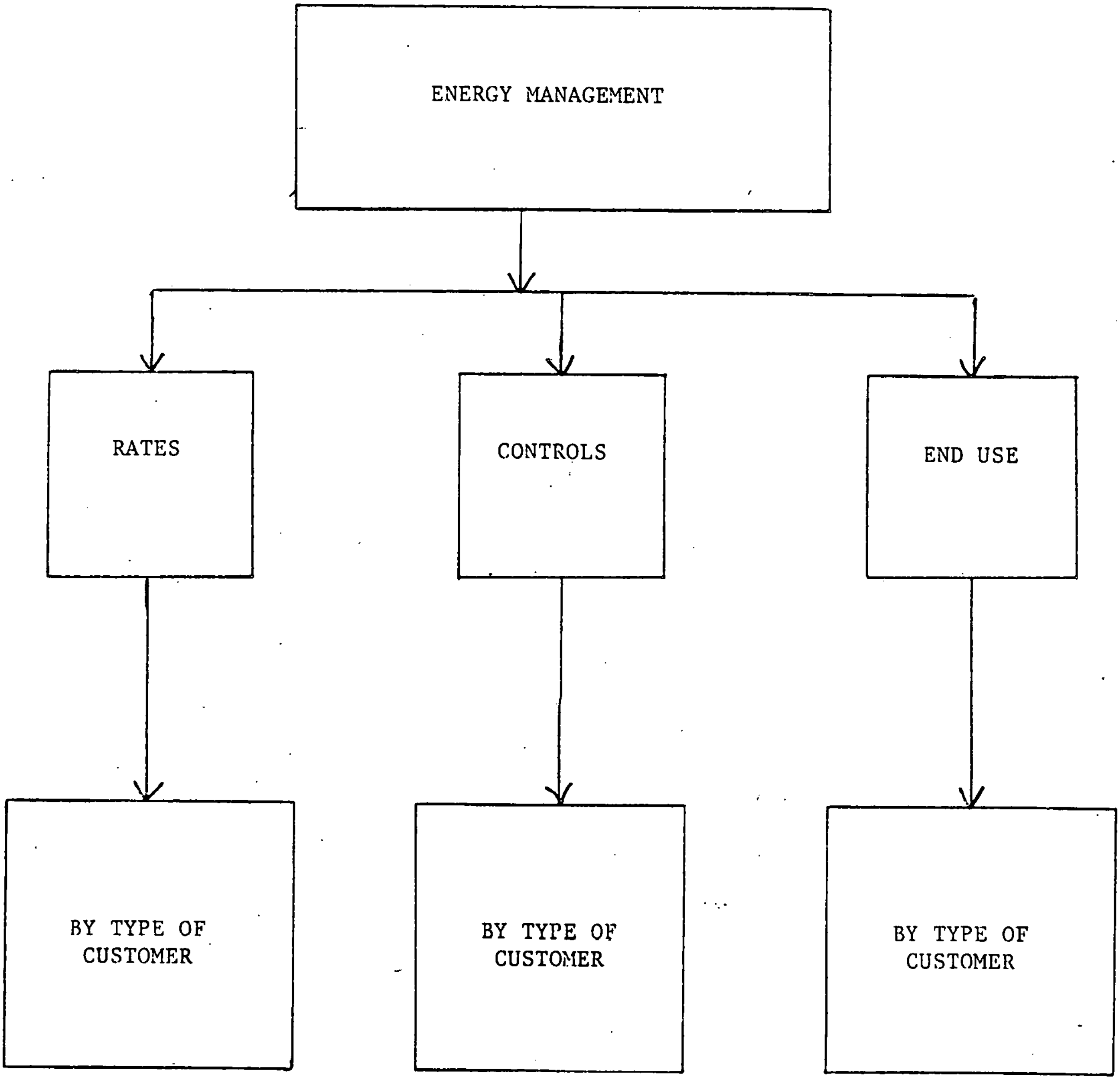


EXHIBIT 9

ARIZONA PUBLIC SERVICE COMPANY
TOU TEST I

RELATIONSHIP BETWEEN PEAK PERIOD ENERGY SHIFTS
AND
PEAK/OFF-PEAK PRICE RATIO
(MAY - OCTOBER)

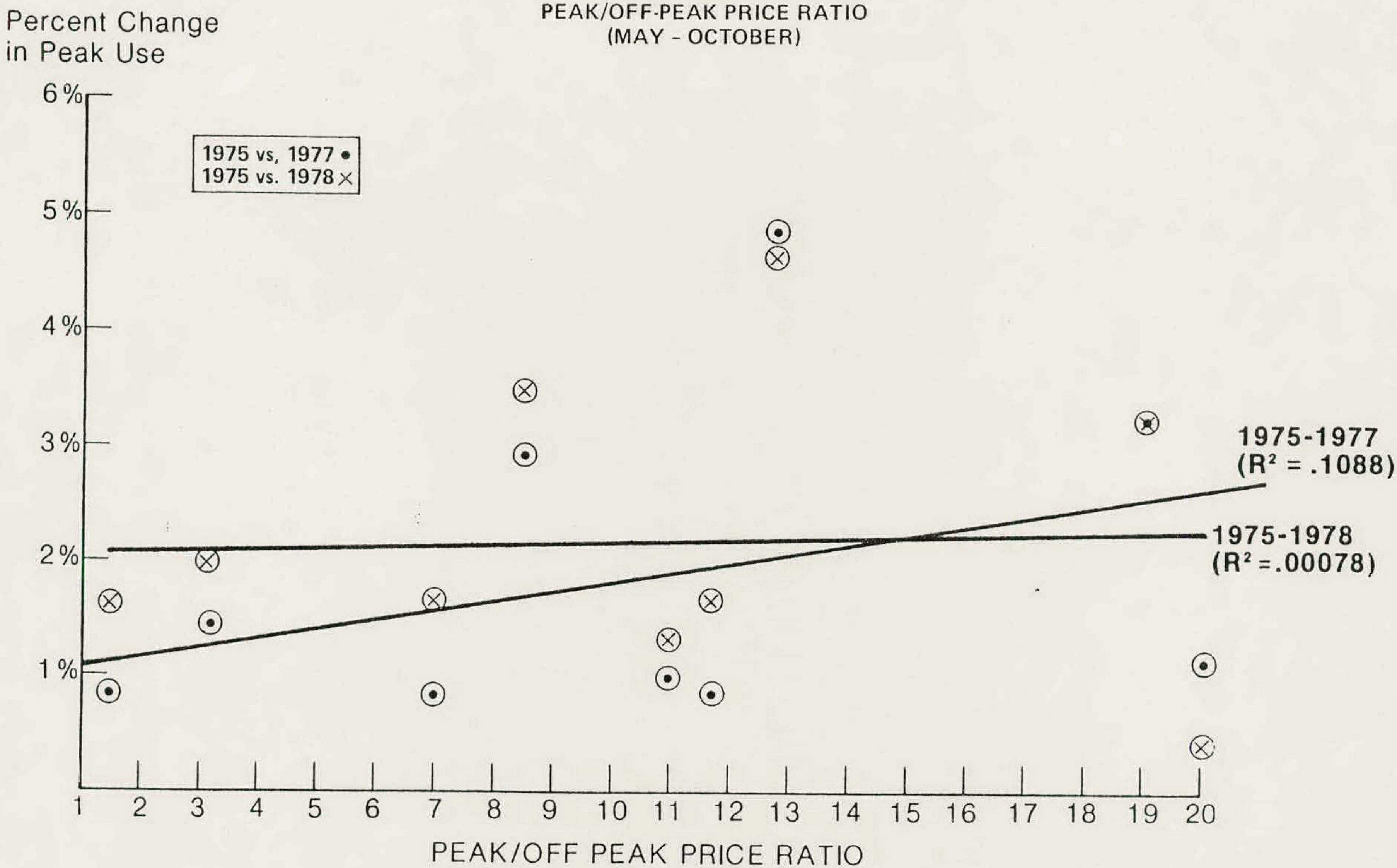


EXHIBIT 10

ARIZONA PUBLIC SERVICE COMPANY

Average Day Profiles for the Month of July, 1978

	TIME-OF-USE	CONTROL GROUP
# of Customers	27	27
Peak Energy (2pm–5pm)	439 Kwh (16.2%)	473 Kwh (18.2%)
Mid-Peak Energy (9am–2pm) & (5pm–10pm)	1336 Kwh (49.3%)	1324 Kwh (50.9%)
Off-Peak Energy (10pm–9am)	937 Kwh (34.5%)	806 Kwh (30.9%)
Total Monthly Energy	2712 Kwh	2603 Kwh
Cooling Type: Heat Pump	26%	26%
Central	74%	74%

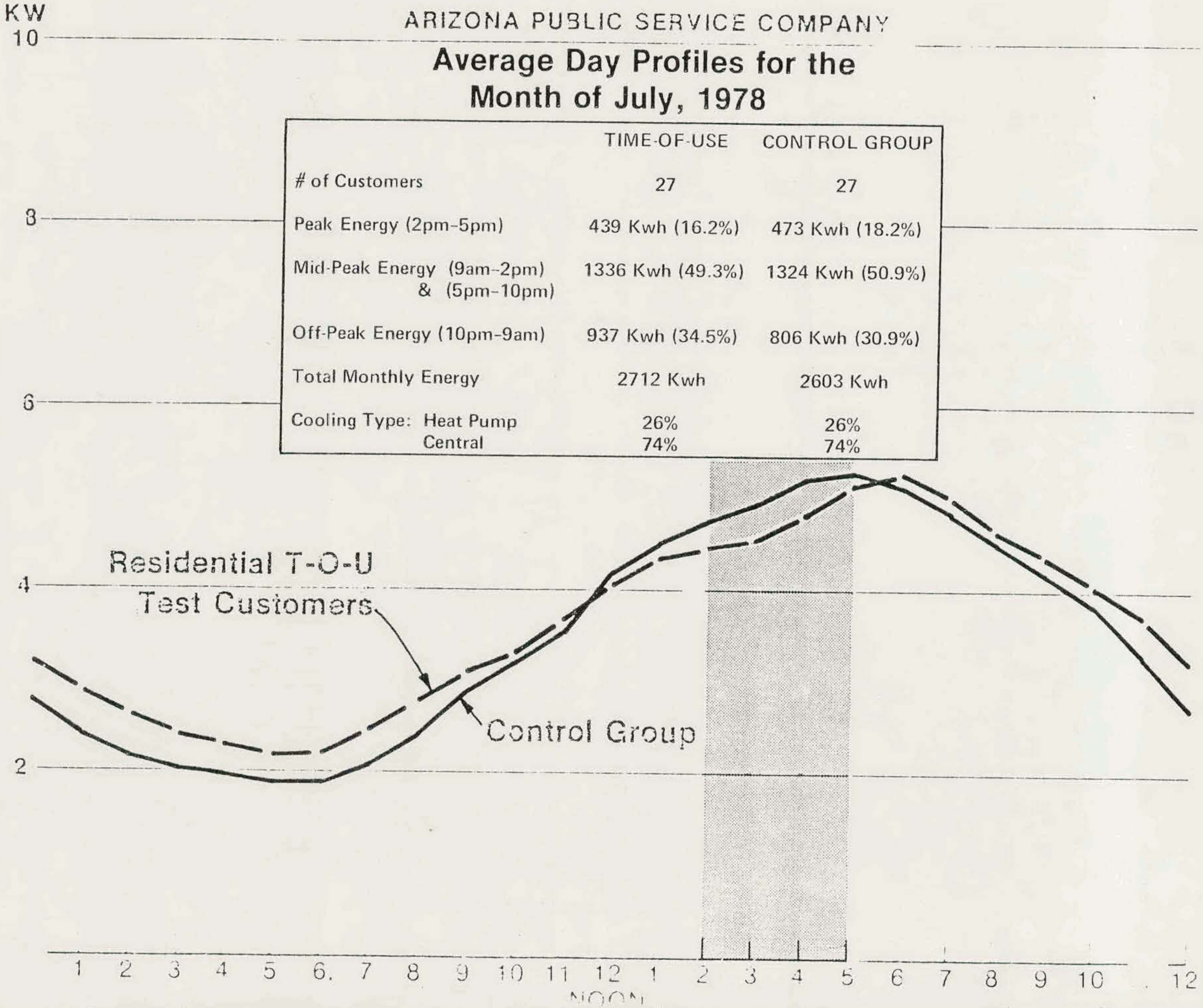


EXHIBIT 11

ARIZONA PUBLIC SERVICE COMPANY

System Peak Day Profiles - July 20, 1978 at 3:00 P.M.

		TIME-OF-USE	CONTROL GROUP
# of Customers		27	27
Individual Avg. Max. Demand		9.21 Kw	9.17 Kw
Sys. Coincident Demand		5.26 Kw	5.23 Kw
Temperature:	At Peak	113°	113°
	Avg. Daily	102°	102°
Cooling Type:	Heat Pump	26%	26%
	Central	74%	74%

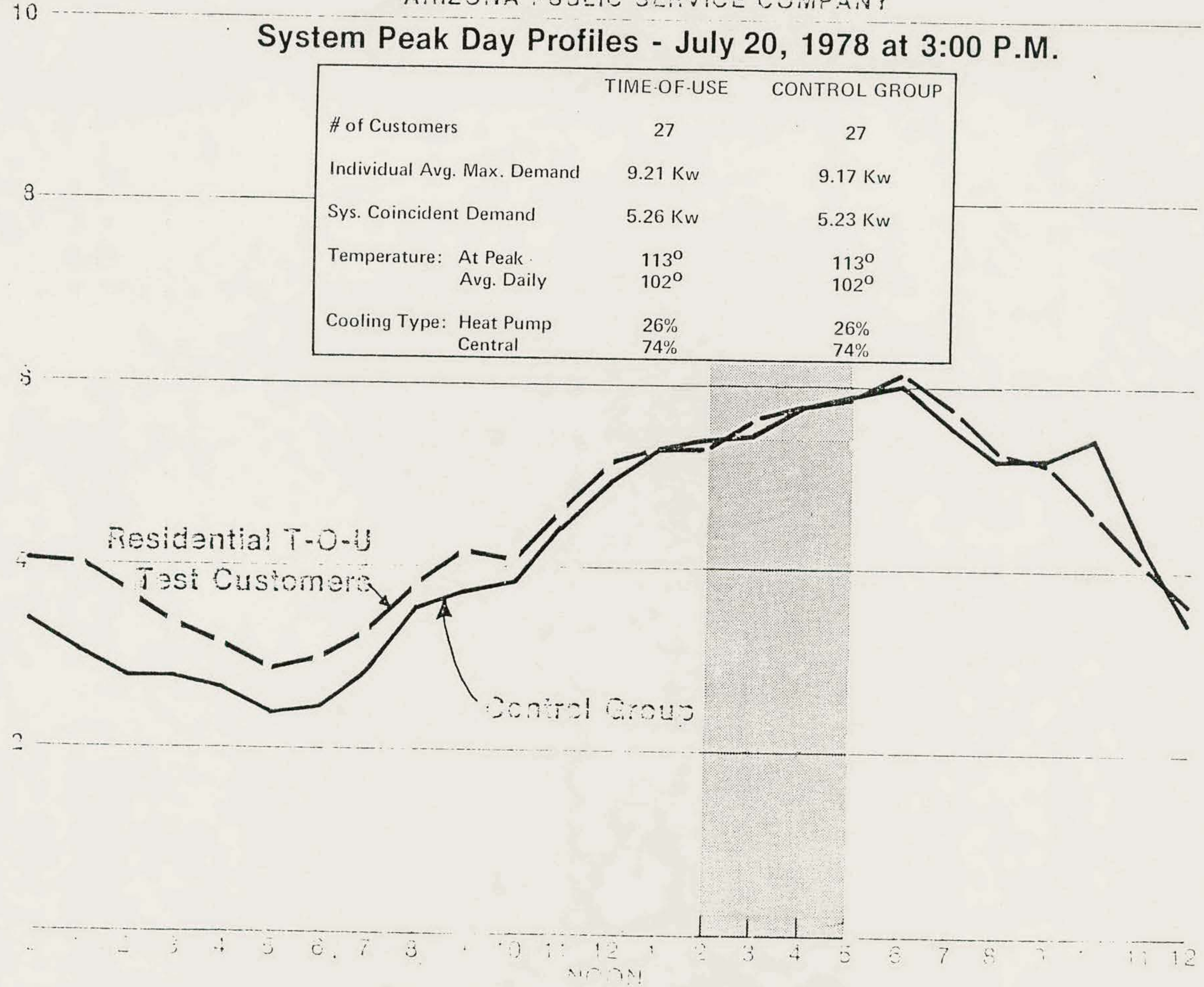
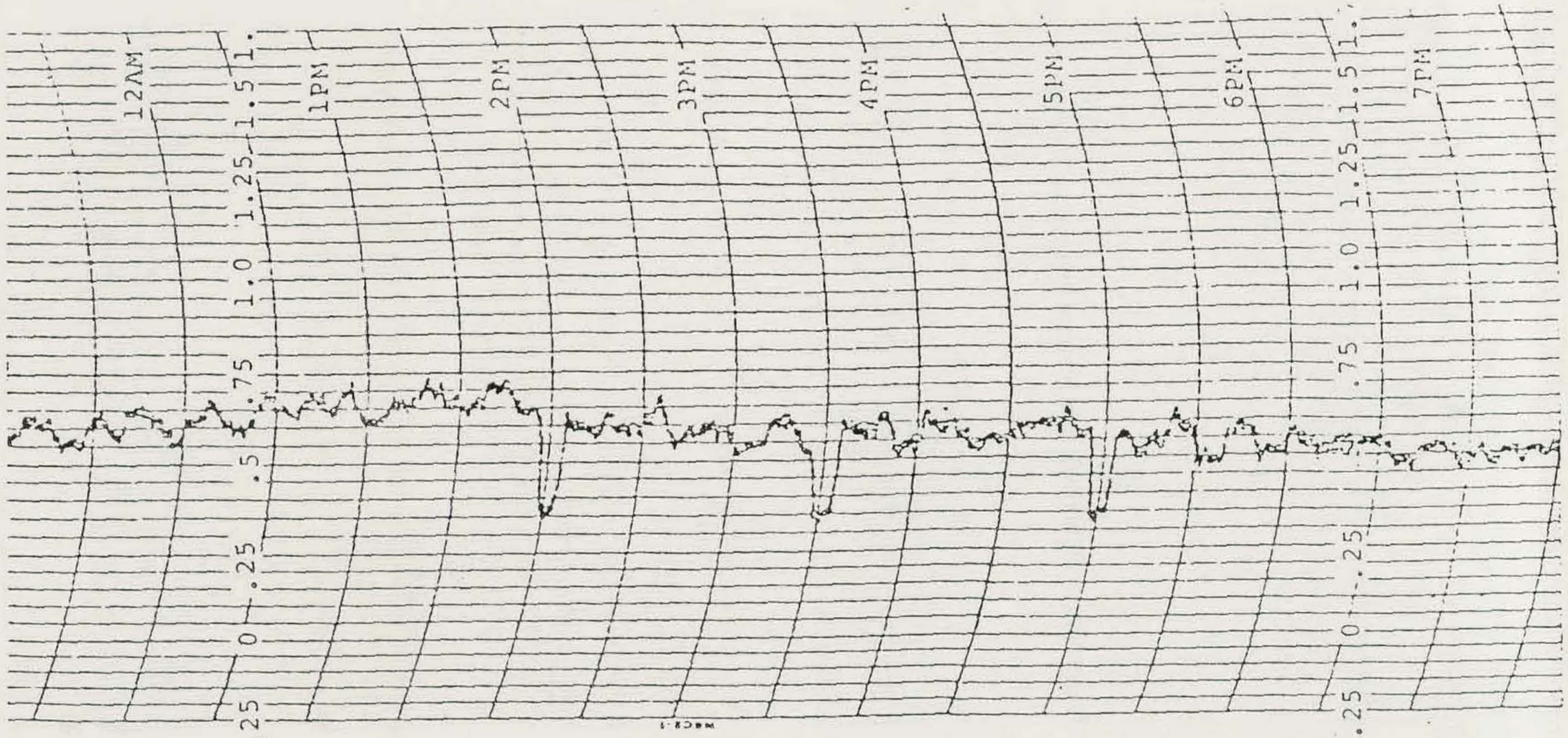
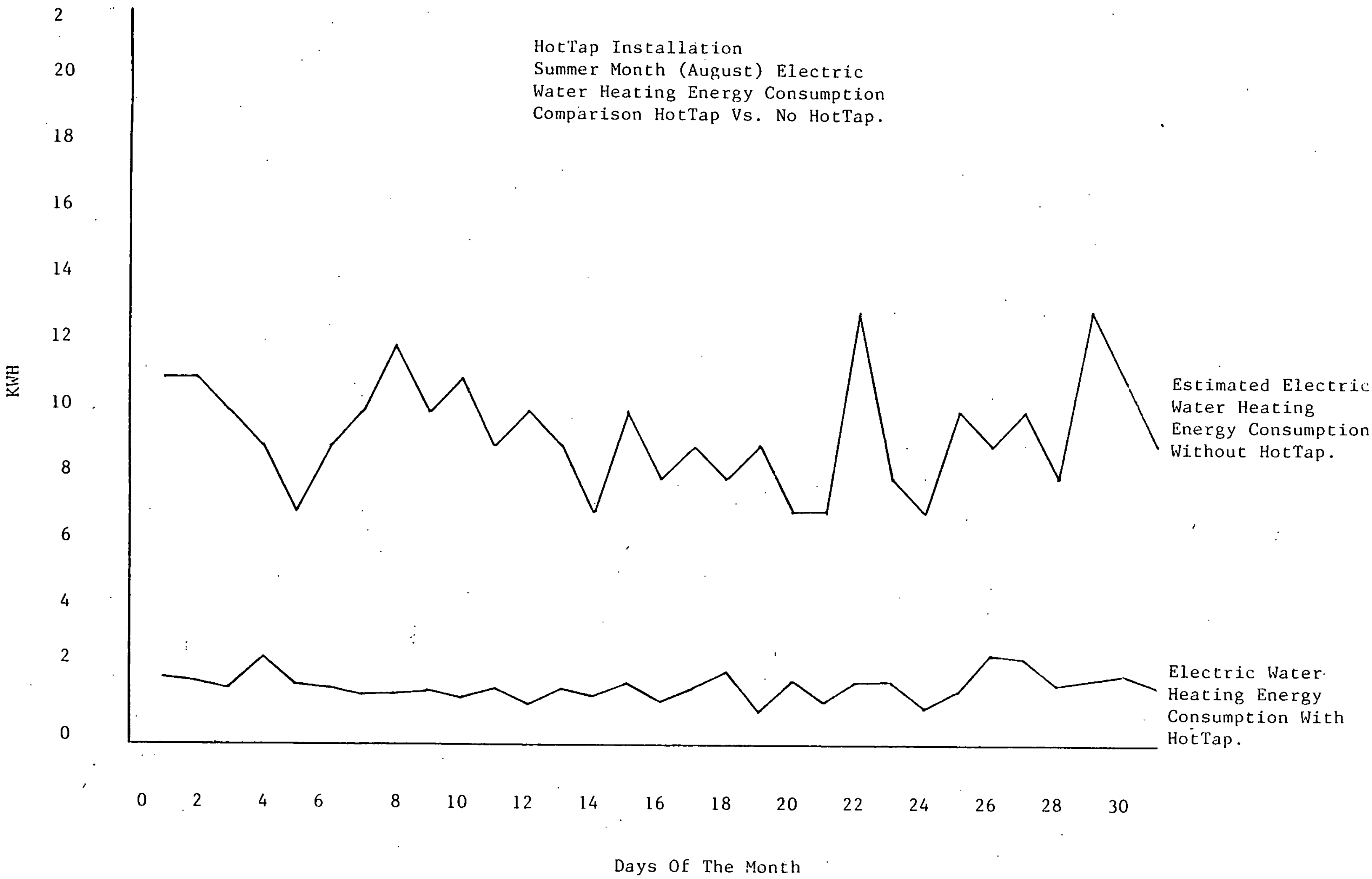


EXHIBIT 12



MONDAY - JULY 26, 1976
2:00 P.M.
3:30 P.M.
5:00 P.M.
3 SHOTS
MULT X 1200

EXHIBIT 13



HotTap Installation
Summer Month (August) Electric
Water Heating Energy Consumption
Comparison HotTap Vs. No HotTap.
KWH
2
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Days Of The Month
Estimated Electric Water Heating Energy Consumption Without HotTap.
Electric Water Heating Energy Consumption With HotTap.

EXHIBIT 14

LR71R01 ARIZONA PUBLIC SERVICE COMPANY PAGE 169
DATE RUN: 1/24/79 ELECTRIC CLASS OF CUSTOMER STUDY - - HISTOGRAM TIME 14:40

8/30/78
NAU - HUMPHREY ST - FLAGSTAFF
AUGUST, 1978

CHANNEL A CHANNEL A

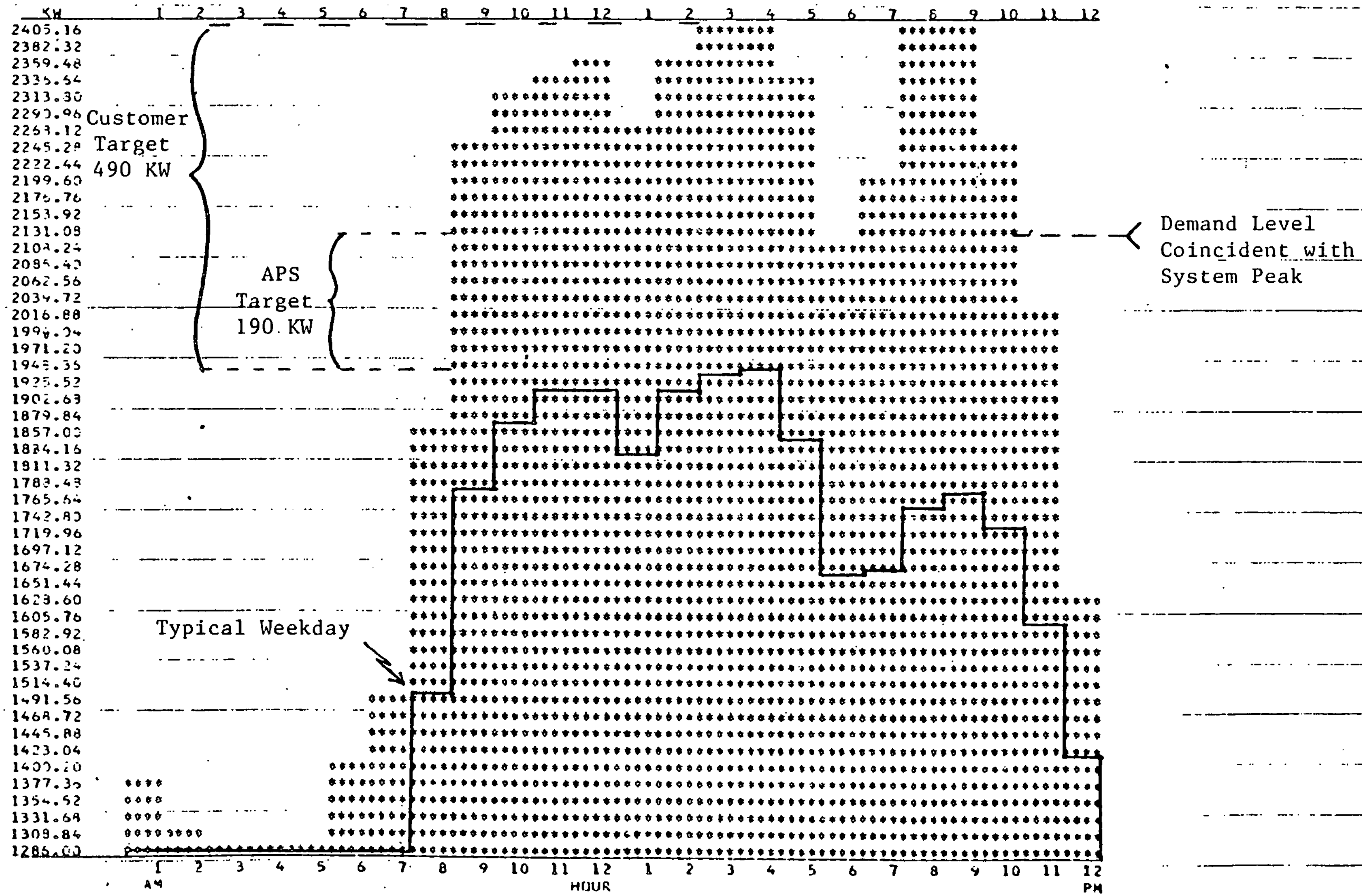


EXHIBIT 15

ELECTRIC AND SOLAR AUGMENT
ELECTRIC WATER HEATER PROFILES

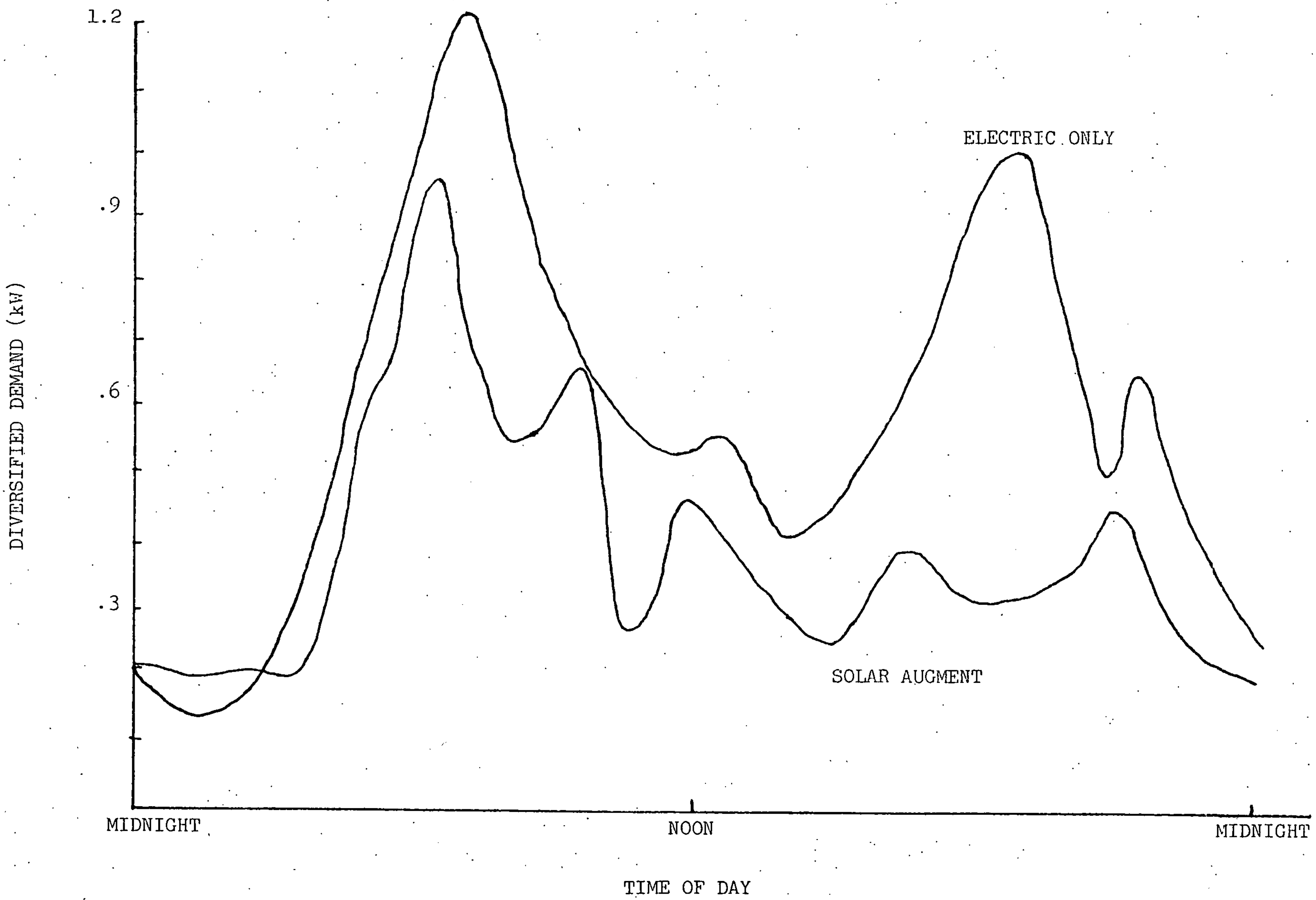
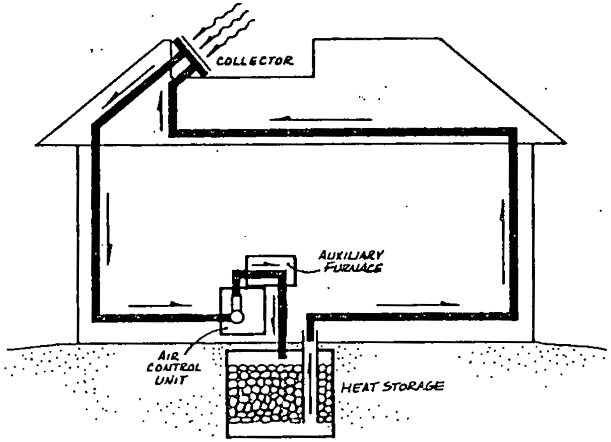
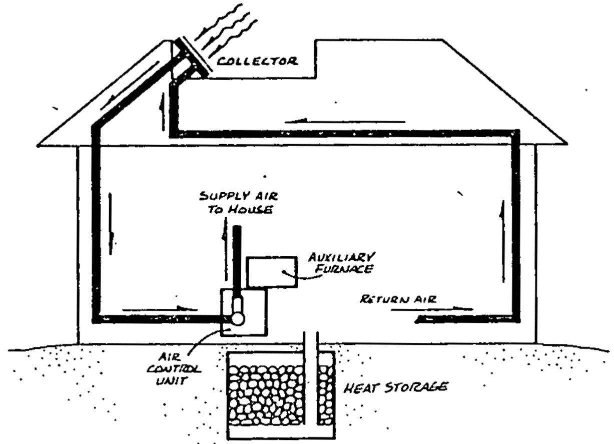


EXHIBIT 16

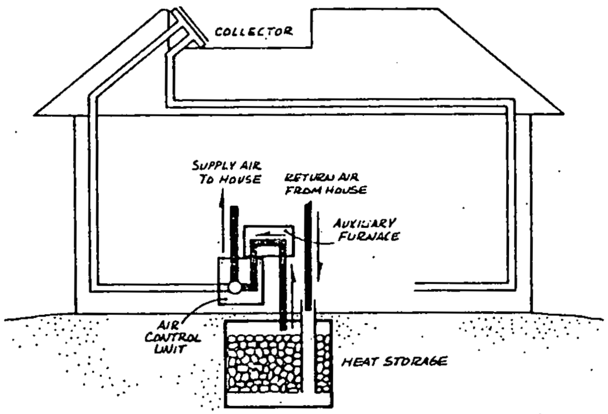
FOUR MODES OF SOLAR COMPONENT OPERATION



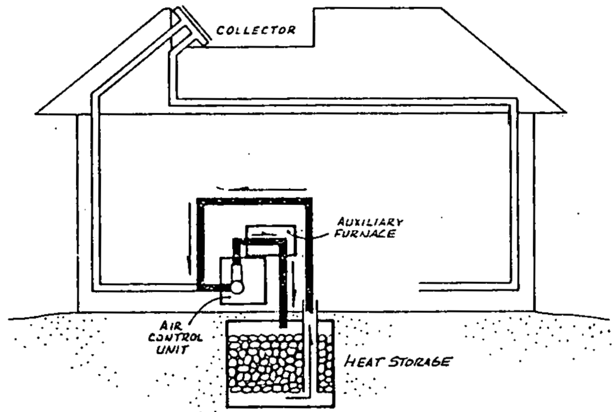
STORING SOLAR HEAT IN ROCK BED STORAGE



HEATING HOUSE FROM SOLAR COLLECTOR



HEATING HOUSE FROM ROCK BED STORAGE



STORAGE OF HEAT DURING OFF-PEAK HOURS

EXHIBIT 17

PURE RESEARCH

1. UNREALISTIC RATES

2. CUSTOMER INDUCEMENTS

3. CUSTOMER TYPES

NO INTERELATIONSHIP MEASUREMENT

1. EACH TEST STANDS ALONE
2. LACK OF "REAL LIFE" RESULTS
3. NO COORDINATION

EXHIBIT 19

SYSTEMS APPROACH

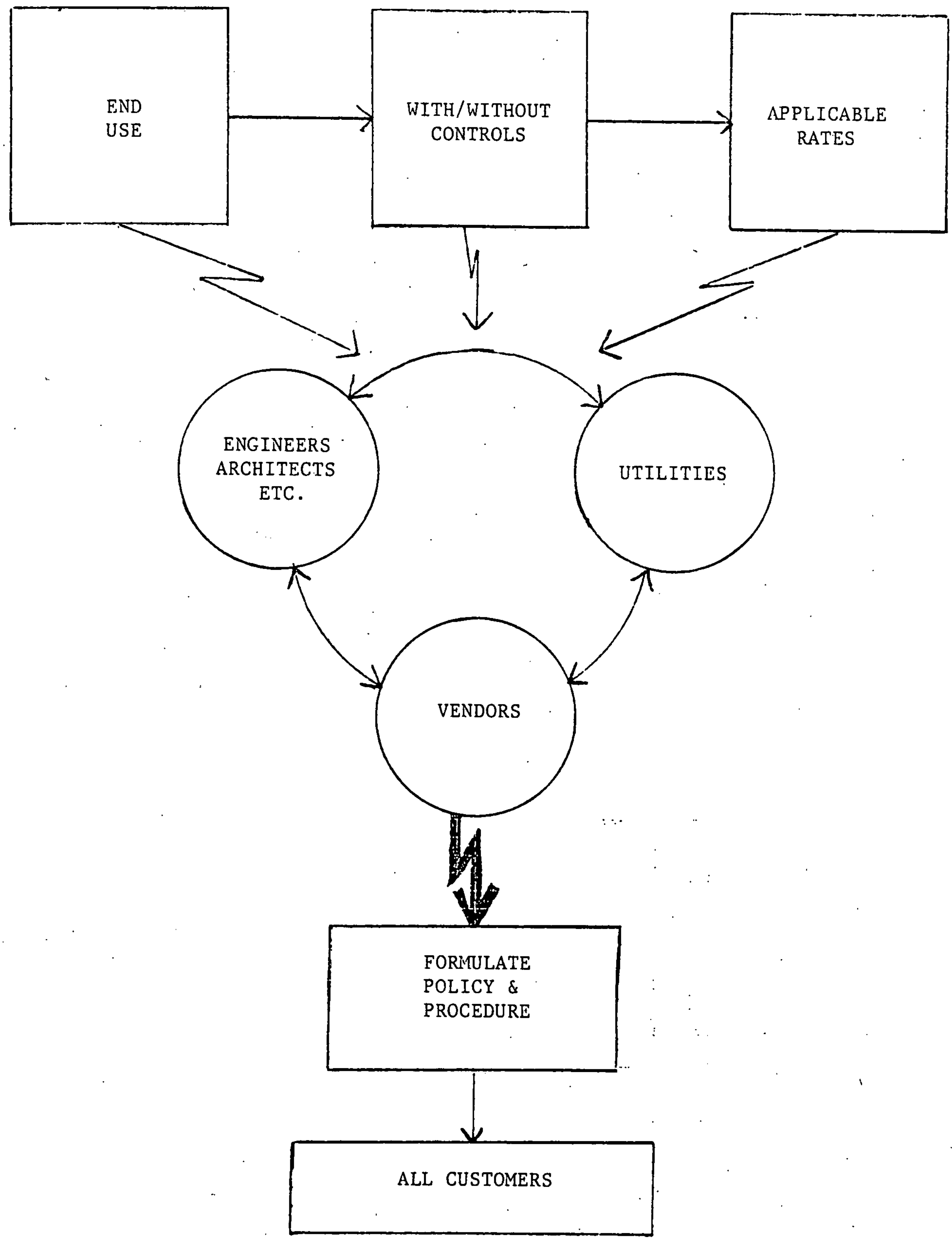


EXHIBIT 20

COMMITMENTS NEEDED

1. STATE AND LOCAL GOVERNMENTS
2. LOCAL REGULATORY AGENCIES
3. UTILITIES, ARCHITECTS, ENGINEERS VENDORS, MANUFACTURERS, AND CUSTOMERS

EXHIBIT 21

BENEFIT TARGETS

1. CUSTOMER AND ALLY INVOLVEMENT
2. IDENTIFICATION OF TRUE PROBLEMS
3. FORCE GOVERNMENTAL AGENCIES TO COMMIT
4. LIMIT LIFESTYLE IMPACTS
5. LIMIT COST IMPACTS
6. TRUE COST/BENEFIT MEASUREMENTS
7. ELIMINATE THE HUNDREDS OF VERY

   SIMPLE "SAVIOR" APPROACHES

   E.G., TIME OF DAY RATES
   INVERTED RATES
   SOLAR CAPABILITIES
   LOAD CURTAILMENTS
   RELIABILITY REDUCTIONS
   VOLTAGE REDUCTIONS
   ETC.

EXHIBIT 22

THE BOTTOM LINE

EQUALS

ENERGY MANAGEMENT RESULTS MUST BE CAPABLE OF BEING UTILIZED TO ACCURATELY IMPACT FORECAST CAPITAL REQUIREMENTS

OVER

THE UTILITY PLANNING HORIZON = 20 - 30 YEARS

AND

THE CONSTRUCTION TIME CONSTRAINTS = 8-15 YEARS

EXHIBIT 23

EL PASO CONFERENCE

CONSERVATION: ENERGY MANAGEMENT BY WHOSE DESIGN AND AT WHAT COST

By Evern R. Wall

The responsibility of the electric utility industry is to supply adequate electricity to consumers, reliably and at reasonable prices. This responsibility is assigned to the utility when the franchise for service is accepted, and from that point on all policies are formulated to achieve this goal. A major key in fulfilling this responsibility is through short and long-range planning.

While my remarks today will be concerned with energy legislation and conservation, I plan to discuss the role of energy planning and involvement at three levels: government, the utility industry and the consumers. All three levels are important; all have a definite role in shaping the nation's energy future.

Government is a very important and expensive part of the equation. We have for many years seen and heard much from the federal government about energy but little in the way of productive action. One of the most striking problems in the 1970's has been the inability of both the legislative and executive branches to formulate a comprehensive, coordinated national energy policy. After many months of political maneuvering, finally we have what is referred to as a National Energy Act. The act consists of five separate bills: The Public Utility Regulatory Policies Act, The Power Plant and Industrial Fuel Use Act, The Natural Gas Policy Act, The National Energy Conservation Policy Act and The Energy Tax Act of 1978. In addition, we also have the Surface Mining Act and Clean Air Act amendments. All of these can be counted on to add substantially to our customer's costs directly and indirectly through increased levels of regulation.

The "Energy Crisis," which came in the fall of 1973, resulted in many things--increased public awareness of the energy problem, "Project Independence" instituted by the federal government, and the beginning of a national conservation program. On April 20, 1978, the President presented to the country his energy message proclaiming the "moral equivalent of war."

Today our country is importing nearly half the oil it uses compared to just over 30% in late 1973. The National Energy Act is lacking in incentives to spur domestic production of petroleum. The Act also is lacking in incentives to further develop nuclear power which is essential to fullfilling the requirements in the Act to convert to alternate sources of energy.

We have seen the charades surrounding construction of nuclear power plants, the administration's continuing effort to deny the nation the benefits of the breeder reactor and nuclear fuel reprocessing and the lack of progress on the spent fuel storage and waste management issues, all obscuring the necessary use of the nuclear option.

While the debate on the nation's energy problem has been the subject of intense interest in Washington for the better part of the last four years, few in or out of Washington have examined the problem except to try and reduce the supply and demand. The overlooked perspective, and the most significant part of the problem, is politics. The supply and demand perspectives are certainly prime considerations in the equation, but political factors have a continuing and significant impact on the conscience and the consciousness of elected and appointed officials. Disorganization in government has lead Congress alone to establish 36 committees, 76 subcommittees and one panel, at last count, to exercise bureaucratic control over the myriad federal energy programs. Add to that the state level energy bureaucracies and, in Texas, municipal political involvement and we have a patchwork of overlapping, expensive regulation overkill.

Concerning the energy business, conspiracy rumors run rampant. It seems that everyone "knows" the Arabs, the government, the "Seven Sisters," and the utilities have all conspired to create the oil embargo and price hikes. As a result, confidence in all these organizations is severely questioned.

The irony is that while everyone "knows" what the problem is and what to do about it, not much has happened as the Country goes merrily along until we once again are jolted into reality by another oil embargo, coal strike, devastating winter weather or who knows what else.

Ahead of us, as the National Electric Reliability Council reported in September, 1978, is the prospect of electricity shortages beginning in the early 1980's as a result of delays in needed power supply facilities caused by counter-productive governmental action and inaction. If power shortages do indeed occur, there is the grave and serious possibility of job losses, business dislocations and social disruptions.

I mentioned planning earlier, and it is difficult for me to warn that such disastrous consequences might lie ahead, however, when you are daily involved in providing energy, you must be a good prognosticator. Planning occupies a large part of our business day. Energy planners can forecast shortages and can also forecast how shortages can be avoided. Using coal and nuclear fuels is the only way we can avert these consequences for the near term while the nation and the industry develop alternative renewable energy sources for the future.

The electric utility industry is the most heavily regulated industry in the Nation. In my opinion, it is in many instances unduly restrictive regulation. However, that is the nature of our business, and we realize that regulation is part of the essentiality of our service, and we accept it.

Since conservation is the subject today, I must say the concept of conservation applies not only to energy and natural resources but also to conservation of time and money. I am speaking of unreasonable and unnecessary, wasteful regulatory exercises that cost time and money. Regulation that takes armies of capable executives away from the vital business of providing energy and causing them to sit through endless hours of unproductive hearings. I'm referring to the kind of regulation which stuffs our files with reams of paper, that creates jobs for hundreds of nonproductive employees causing them to answer the same questions over and over and to send out floods of reports that end up stuffing other people's files. Regulation that requires the Company to prove its point in monotonous detail to first one regulatory, then another and even beyond. Regulation that costs money, money which is coming out of the pockets of our customers who then blame the utility through which these costs are paid. Regulation which is often counter-productive, politically motivated and emotionally reactive.

I will conclude this section of my presentation by mentioning a potential partial relief from some of this expensive, regulatory overkill. Bills have been introduced in both the Texas house and senate which would amend the Public Utility Regulatory Act to give the Public Utility Commission of Texas exclusive original jurisdiction over electric rates and service in Texas. Large sums of money can be saved by the consumer if the utilities were allowed to present their complete case only one time. Single jurisdiction also would result in savings to the local government by freeing municipal staffs to work on other important issues. All these savings would be passed along to the consumer. At a recent legislative hearing the PUC testified that elimination of hearings at the municipal level would result in significant cost reduction for the state. I ask your support for these bills.

As for the regulated, the utilities, the second portion of our equation, we plan in the face of the present barrage of government regulation and energy legislation to simply to what is necessary and to do it well.

Planning is essential for electric utilities. We are the ones who must meet the energy requirements of our customers 10 or 20 years in the future, not newspaper reporters, not political opportunists who are vocally on the scene for a fleeting moment and then heard from no more.

Our industry has a proven track record in providing reliable electric service. In 1974 things were looking pretty good for electric utilities. We had a steady peak load growth of 7% per annum; there was a three to four year lead time for a new generating plant. El Paso Electric was installing gas-fired generation at a cost of $150 per kilowatt. Today, as you know, things are quite different. Utilities are no longer the invisible "good guys," but are quite visible whether they want to be or not. Construction of new coal or nuclear generating stations costs $1,000 per kilowatt and takes 10 to 12 years to complete. Peak load growth has lowered somewhat, to about 6% in our service area according to most load growth forecasts. Utilities in the "snowbelt" have even lower peak demand forecasts, to near the 4% level. Things have really changed.

Even Reddy Kilowatt, the symbol of our industry, has undergone a change. Ten years ago Reddy was a major promoter of electric consumption. Reddy now, instead of pushing electric consumption, is urging us to cut our use of electricity and adjust to the new era of conservation. This transformation symbolizes one of the changes in the electric utility business. What has happened?

Actually, experts have been warning us since the 1950's that the nation's appetite for energy would eventually exhaust our diminishing oil resources. But our our nation did not want to curb its enormous consumptive habit and was not listening. Only now are we starting to waken to the need for conservation of our nation's energy resources.

The National Energy Conservation Policy Act is one-fifth of the new National Energy Act. President Carter has made conservation the cornerstone of the nation's energy policy. Conservation, I believe, is certainly a valuable part of the total effort. It will play an important supporting role as the utilities are required by the new regulations to shift emphasis from oil and gas to coal and nuclear.

Conservation in the most optimistic view can provide about 32 of the 148 quads of energy that will be needed by the year 2000 if we continue the present use pattern. Conservation will require certain changes in lifestyles. To achieve the necessary savings may require more changes than many may be willing to make. I think we can all see the value of conservation, but it clearly is no panacea in itself.

One interesting point is that in the conservation act passed by Congress there are provisions encouraging the use of bicycles in the United States to eliminate where possible using cars or other mechanized transportation. At the time the most advanced technological nation in the world is encouraging bicycles, one of the most backward countries, China, sent Teng Cho Ping to the United States on a mission to see how China can get away from bicycles toward more modern transportation.

El Paso Electric and many other utilities across the nation were already beginning to urge energy conservation to consumers in the early 1970's. Our Company has created an Energy Utilization and Conservation Department which has for a number of years performed many of the things now required by the new conservation law. Energy audits, information on the efficient use of energy and information about proper insulation has long been part of our program. The industry through the Edison Electric Institute had its National Energy Watch program before the law was passed. So we are and have been committed to conservation. But again I must warn that there is more to conservation than just turning out the lights.

In order to preserve domestic oil and gas and to insure continuing adequate and reliable energy source for the future, our Company started planning early in 1960 to install generating capacity which would save petroleum fuels.

The Company participated in coal-fired generation in 1973 when Four Corners Unit No. 4 went into service near Farmington, New Mexico. The very next year Unit No. 5 went into service, and our Company was again part owner, supplying our customers with their first coal-fired electricity.

Approximately 18 percent of the Company's generating capacity is presently being provided through the use of coal. Later, our planning indicated the continued need to conserve oil and gas. In 1974 we installed a combined cycle, 240 megawatt generating unit at Newman Station. The combined cycle uses a process which burns oil or gas through two combustion turbines and dumps excess heat into a steam boiler, providing additional generation. This particular procedure has saved thousands of cubic feet of gas and hundreds of barrels of oil during the past few years because of the efficient use of waste heat.

Early in the 1970's, studies indicated that nuclear generation would be the most economical choice for our customers in the future. At that time the Company indicated its desire to become a participant in the Arizona Nuclear Power Project. The project soon became the Palo Verde Nuclear Generating Station and started with the organization in 1970 of a Task Force manned by Arizona Public Service, Salt River Project and Tucson Gas and Electric. The study group was responsible for examining the safety, environmental, economic and technical liability of utilizing nuclear energy to meet the future power generation requirements of the Southwest.

Following the completion of the studies, many utilities were asked for a show of interest in joining the Arizona Project. The broad invitation was made to satisfy antitrust requirements of the Atomic Energy Act of 1954.

Tucson Gas and Electric, El Paso Electric and Public Service Company of New Mexico formally joined the project in August, 1973. In December, 1973, the Arizona Electric Power Cooperative also became a participant. Later, Tucson announced that its 15.4 percent had been acquired by Southern California Edison Company, and AEPC requested that its share be reassigned to APS, SRP and SCE as provided in the original agreement.

El Paso Electric believed then and believes now that the decision to participate in ANPP was wise and correct and in the best interest of the Company and its customers.

EPE's participation in the Arizona Project has been the subject of considerable discussion by members of the local governing bodies and news media within the Company's service area. It must be noted, however, that there has been no broad negative public reaction to the Project. To the contrary, survey after survey has indicated that the public generally accepts and is supportive of nuclear generated electric power.

Stated simply, EPE decided to participate in the Project because, based on the Company's future load growth projections, it was found that additional base load generating capacity, such as could be delivered by Palo Verde, would be required in the 1981-85 time frame, and the cost and availability of traditional fuel supplies eliminated them as a future source. There were many important factors which weighed heavily in the Company's decision to participate in the nuclear project: it allowed diversification of the Company's fuel mix, it permitted the use of an available source of water, it provided an opportunity for the Company to strengthen its transmission interconnections with other utilities and last, but certainly not least, future energy cost strongly favored participation in Palo Verde.

The economic attractiveness of Palo Verde grows with each passing year. At the time of the Company's decision to participate, the handwriting was already on the wall that state and federal governments were seriously reviewing the price and availability of conventional boiler fuels.

Given this scenario, without adequate supplies of traditional boiler fuel supplies, the Company was faced with determining the alternatives in order to guarantee an uninterrupted power supply to customers in the time frame being considered. The choice was simply we must convert our base load generation to coal and nuclear fuel in order to conserve oil and natural gas.

The Company's position concerning its decision to participate in Palo Verde has not changed. In view of events subsequent to entry into the project (the energy crisis, oil embargo, the winter and the coal strike of 1977), the decision appears even more prudent and in the best interests of everyone concerned.

While construction of new generating facilities is becoming more and more expensive, as inflation and regulatory factors take their toll, we in the energy producing business are confident that nuclear and coal energy will continue to provide great benefits to the nation. I would far rather explain to all of our customers that higher rates are necessary to help support our construction program than to have to explain to just one customer someday why power must be curtailed because of a shortage of generating capacity.

Which brings me to the third and final part of our energy equation, the public.

One of the most interesting aspects of the equation is that public perceptions of energy matters seem to display a lack of realism, mixed with liberal amounts of wishful thinking. Consider some of the recently released results of a nationwide survey completed in mid-1978 by Response Analysis. Concern about the energy crisis is declining; only one-third of the public believes electricity may be in short supply in the future. There is strong optimism that there is plenty of fuel for electricity production, coupled with the belief that, even if shortages occur, new fuel sources will be found. Consumers also believe that sacrifices are unnecessary, because there is no energy or electricity crisis now and, consequently, no new plants will be needed, rates will not have to be increased, pollution laws need not be relaxed, and more R&D at higher prices is unnecessary, and a general belief that the industry is pushing nuclear and coal power while dragging its feet on solar energy production.

The statistics are apalling. Clearly, the public's nonappreciation of the realities of the energy problem; its nonacceptance of the need for new electric generating facilities, its growing opposition to nuclear power, its conviction that there is no requirement for more R&D indicate many misunderstandings of the energy problem in general and of our industry in particular.

I am not certain how to overcome this credibility problem, but it is our hope that people will not be swept up in an overly optimistic outburst and be mislead into believing that solar energy for electric generation is the answer to all of the country's perplexing energy problems. The same applies to geothermal, Biomass, ocean thermal gradients and any number of other "exotic" energy alternatives that have barely progressed to the theoretical, let alone the experimental stages.

Sometimes it seems that the public is more willing to accept an empty promise as an energy alternative than to accept a known source which is available at the time it is needed.

In most areas of the nation, nuclear electric plants produce the lowest cost electric energy.

The most important concerns of Americans today are inflation, high taxes and other extreme economic pressures. Even so, there is a movement to scrap the lowest cost electric generation available and deny these savings to the public.

One of the crucial elements in the complex energy problem has to do with the recycling of misinformation or an information gap. The gap does not involve insufficient information nor lack of effort communicating it. Rather it seems that the gap is, as one of my friends put it, a kind of "Black Hole" in the universe of public understanding, into which factual material is poured with little apparent effect.

To deal with this phenomenon, we in the utility business try to use all the information we receive from customers regarding their concerns, their beliefs, their perceptions in our attempt to work out a strategy to bridge the gap effectively.

Thank You.

STRATEGIC PLANNING FOR AN ELECTRIC UTILITY IN AN ERA OF UNCERTAINTY AND CAPITAL CONSTRAINTS

Lawrence E. De Simone
Manager, Strategic Planning Department
San Diego Gas & Electric Company

Introduction:

The objective of my presentation this morning is to address strategic planning in the electric utility industry, given that this industry faces an era of extreme uncertainty and severe capital constraints. To accomplish this objective, I will review the electric utility planning process from a historical perspective, identifying how planning has been done, how it is changing, and how it will be conducted in the future. I also hope to identify the way in which the various strategies discussed at this conference will have an impact on the utility planning process, both today and in the future.

The Traditional Electric Utility Planning Process

As a backdrop for our discussion today, I would like to review for a few minutes how planning has been conducted traditionally within the electric utility industry. For assistance in this discussion, I ask that you turn to Slide #1. Slide #1 represents a simple schematic of the traditional electric utility planning process. Within this slide, the sequence of planning is from top to bottom. Utility planners start with estimates of demand for electric energy (Kwh) and peak demand (Kw). Based on estimates of future demand, planners evaluate the costs and reliability of various supply options in order to determine what resource additions are necessary to enhance (in a sense, optimize) the existing or future supply system. These planned resource additions constitute a construction program which must be supported by a combination of internal and external financing. The financial planning element represents the third and final part of the traditional planning process.

This one-way directional flow of planning from demand estimation through supply determination and on to financial planning is characteristic of traditional planning within the electric utility industry. Our major emphasis historically has been supply determination; that is, what types of facilities should we construct to meet ever growing electrical demand? Engineers played a dominant role in the planning process because of the intricacies of engineering evaluations relative to the apparent certainty of demand patterns, the ever decreasing unit costs of providing power, and the strong financial health of the electric utility industry. It was not unheard of for engineers to project demand patterns with a ruler, select proposed resource additions through careful analysis, and simply inform the utility financial officer that a certain level of funding was required to support the construction program.

Factors Which Have Recently Changed the Planning Problems

Fortunately, or unfortunately, depending on your perspective, this historical planning process has changed significantly over the last five years. There exist at least five major factors which have necessitated this change.

The first major factor is that the growth in electric demand has been much more eratic than the general trend extrapolations that were expected prior to the oil embargo of 1973-1974. Because these smooth trends of demand growth no longer exist, there exists a need to analyze various factors that have an impact on the demand for elasticity. As you can see from Slide #1, I have taken the liberty of identifying those major demand determinants that are considered in developing demand projections today. These determinants include weather, demographic growth, economic growth, the price of electricity and associated rate designs, the price of natural gas, oil, and other substitute fuels and their associated rate designs. The perceived availability of alternative energy forms and finally, conservation and load management. A second point worth making is that the various demand determinants cannot be assessed easily in isolation of one another. Strong interactions and interpedencies complicate such assessments. Beyond the obvious linkage between economic and demographic growth, there exist strong linkages between electricity prices and rate designs and the rapidity of penetration of various non-generation options. High bills can accelerate implementation of load management equipment, or at least demonstrate to regulators that such equipment is cost-effective. At the very least, determination of future demand patterns is much more difficult than traditional trend extrapolation. Another important facet of the changing demand issue is that conservation and load management present the utility planner with considerable uncertainty. Planners have very little historical experience with the so called non-generation options. This lack of experience tends to create doubt regarding the potential long-term effectiveness of such factors. A case in point is the successful but short-term patristic conservation exhibited voluntarily by U.S. consumers during the Arab oil embargo of 1973-1974. This doubt is softened, but not eliminated, by the implementation of mandatory standards which require conservation of energy through new appliance and new building efficiencies.

The second major factor that has changed the historical planning process is that supply has become more uncertain. There is considerably more uncertainty regarding the costs of constructing new facilities of the timing involved in bringing a new plant on-line. Licensing and environmental issues are the primary elements responsible for this increased uncertainty. The manner in which new facilities will be financed is also an issue that places additional uncertainty on supply. Historically, analysis of supply uncertainty focused on the outage rates and reliability of generation system. Currently, the question is not whether in the future a plant will be down for a particular period of time due to some unplanned event, but whether the plant will be even licensed, constructed and available for operation at that particular point in time.

The third major factor which has modified the traditional planning process of the electric utilities is the feedback between the financial element in the planning process and the demand element in the planning process. The rates charged for electricity and other forms of energy have a significant impact on the demand utilization patterns for those energy forms. The current and future rates for electricity are very much dependent on the financing programs of the utilities. Because these financing plans are predicated upon expansion (construction) programs it is apparent that construction plans can influence demand patterns via the financial planning link. By necessity, we must now evaluate the potential implications that a particular construction program might have on demand profiles through the financial planning-ratemaking loop. Assumed demand projections are not stable with respect to future rate scenarios until there exists some convergence between the rate assumptions upon which demand projects are based and the rate projection derived from a particular financing plan which are derived from a particular construction program designed to meet fixed demand requirements. We frequently refer to this characterization of the feedback between finance, rates and demand determinantions "closing the loop."

A fourth major factor which has modified the historical planning process is the enhanced role of the financial planner at electric utilities. As I indicated in earlier remarks, traditional planning within a utility has been a one-way process focusing sequentially on demand determination, supply optimization, and financial planning. However, because of regulatory constraints in the ratemaking arena and the inability of the utilities to raise capital as readily as was the case historically, we find that this traditional process is frequently reversed. Ceilings on anticipated rate increases necessitate ceilings on financial programs, which tend to constrain construction programs. Given that demand cannot exceed supply, planners are now forced to examine the possibility of modifying reliability standards or even demand itself.

The fifth and final factor which has modified the electric utility planning process is the fact that there exists a variety of factors which must be considered today. The intricate interactions of demand, supply and financial elements with each other and with various external factors adds considerable complexity to the planning problem.

An Alternative Planning Tool

In view of the five major factors identified above, it has become necessary to modify the planning process within the electric utility industry. While there exists no single tool which can answer every utility problem, we can discuss some conceptual approaches to this issue. At this time, I do not wish to expound the virtues of elaborate corporate planning corporate models which have been used and abused. Nor do I intend to advocate a particular methodology for the sake of the methodology. Instead, I would like to discuss a simple decision making framework which is slowly working its way into the utility planning process. This framework is presented on Slide #2 and consists of three basic components: alternative actions, states of nature, and, outcomes. The alternative actions or "strategies" are represented by the Ai's on the left side of the "outcome table." These alternative actions may include various investment opportunities, marketing tactics, etc. available to a firm. The states of nature are identified by the Sj's across the top of the outcome table and represent the various environmental conditions, external to the firm, which could impact any strategy. The outcomes are illustrated by the Oij's within the table and represent the result of pursuing a particular action and encountering a particular state of nature.

In its simplest form, we can use a decision analysis framework of this type to evaluate the outcomes which might result from pursuing particular strategies. Obviously, we must be able to identify what alternative actions are available, what states of nature could occur and what outcomes are important to the decision maker. Identification of alternative strategies is difficult without a comprehensive view of the firm and its associated environment. Identification of potential states of nature is difficult because of rapidly changing environmental conditions.

The amount of information regarding these states of nature will determine whether we are dealing with a situation of risk (probabilities available) or uncertainty (no probabilities available). Identification of appropriate outcomes or goal measurements is difficult because we frequently find that no single outcome suffices; instead, we are forced to evaluate an entire vector of outcomes, or an entire matrix of outcome tables.

Application of Alternative Planning Tool to Electrical Utility Planning Process

Slide #3 represents an attempt to apply the decision making framework to the complexity and uncertainty present in the utility planning environments. This slide bears some resemblance to Slide #2, although Slide #3 contains considerable detail in the large center box which emphasizes the complex interactions of demand, supply and financial components. Alternative actions appears on the left side of this diagram, external environmental factors appear at the top of the diagram, and outcome factors (evaluation criteria) appear on the right hand side of the diagram.

The center block in Slide #3 contains a much more global identification of three traditional elements of the supply planning process. Demand for total energy is analyzed from the perspective of individual customer groups (residential, commercial, etc.) and specific end-uses (space heating, water heating, etc.). The supply element, which is the entire bottom portion of the large center interaction block, contains reference to the fact that a multitude of products (e.g., electricity, natural gas, steam, non-generation alternatives) marketed by either a utility or another firm can now contribute to satisfying market share. This competitive complexity means that utilities no longer possess the same market power that was present a few years ago. This is particularly true when it comes to offering products from the inventory of non-generation options. In addition to pursuing an output mix in a semi-competitive environment, utility planners also have some control over the input technologies which will be utilized to produce the output mix. Thus, I have identified under each specific output the alternative technologies available to produce this output. For example, under the electricity heading within the utility portion of the supply component, I have identified oil, nuclear, coal, etc. as technological options. Where does energy management fit into this analysis? As you can see from the diagram, this service is currently considered as a non-generation option designed to satisfy service area energy demands through demand reductions. This product is available to consumers from both the utility and the private sector. The finance element is presented in the upper right portion of the large center interaction block. Financial items of concern include basic operational information, cash flow considerations, sources and uses of capital and finally rate base, which is the asset base upon which utilities are presently premitted to generate a return.

One of the more interesting components of Slide #3 is the evaluation criteria (outcome) component. Note that most utility planners must assume dual personality. On the one hand, because many companies are investor-owned, utility planners must pursue strategies which assure financial integrity of the company. In addition, goals such as minimum customer cost, minimum corporate risk (particularly given a ceiling on return), maximum management flexibility and exemplory behavior within the industry tend to motivate planners. On the other hand, because utility companies are heavily regulated, utility planners must possess a social conscience. Energy efficiency, environmental quality, energy costs, and resource preservation become primary goals under this perspective. The utility planners are frequently presented with a dilemma because many of these identified goals are not easily attained simultaneously. In fact, at times these goals can be mutually exclusive, which requires considerable judgment on the part of the utility planner.

The states of nature or external environmental and considerations are identifed at the top of the diagram. This box serves to remind us that in addition to the complex economic environment, utility planners must also anticipate changes in the regulatory and political environment as well.

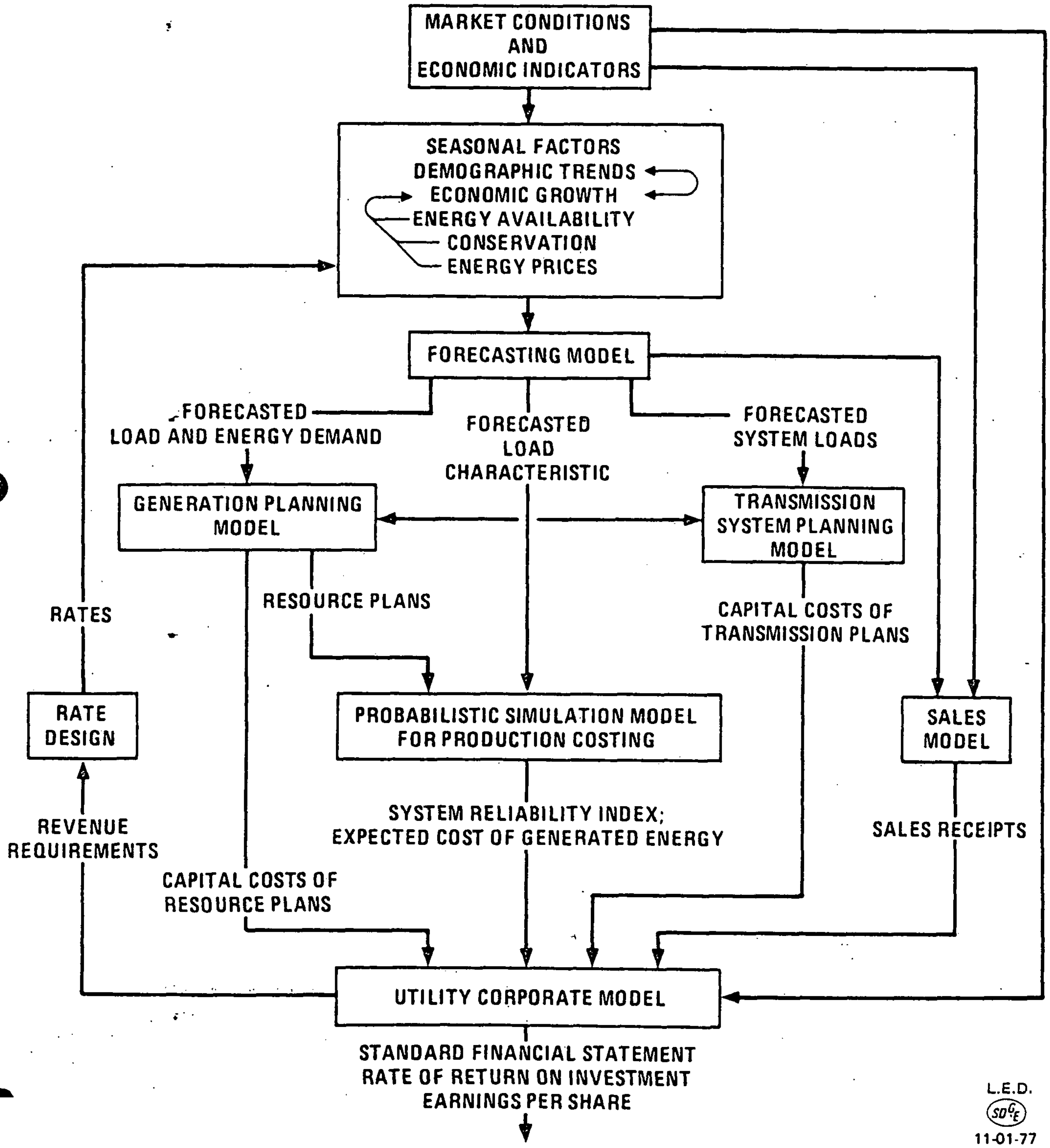
The alternative strategies available to utilities appear in the box on the left side of the diagram. It is not accidental that this box is small, for in fact utility planners have very few options available when compared to planners in unregulated industries. The utility planners have been regulated for a number of years and as a consequence the innovative strategy development that you may see in other industries is just starting to develop in the utility industry. A good example of such strategy development is that the telephone company is taking a much more market orientation toward the world. The strategies which I have identified include demand strategies oriented toward modifying demand patterns through promotions, rate deisgns, planning, R&D, supply strategies which emphasize the selection product mix and input technologies to produce the product mix, and finally a financial strategy which focus on capital investment, operating costs and external financing.

Conclusion

Utilities have traditionally been successful in developing traditional supplies. We have also seen considerable creative thinking in the financial planning process. Clearly, the remaining issue is the degree to which utilities can initiate efforts to modify demand and penetrate these newer competitive markets with a product line of non-generation options.

ELECTRIC UTILITY PLANNING PROCESS

SDG&E
San Diego Gas & Electric Company



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SDG&E
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DECISION ANALYSIS FRAMEWORK
OUTCOME TABLE

STATES OF NATURE (S_j)

ALTERNATIVE ACTIONS (A_i)

	S_1	S_2	S_3	S_4	...	S_n
A_1	O_{11}	O_{12}	O_{13}	O_{14}	...	O_{1n}
A_2	O_{21}	O_{22}	O_{23}	O_{24}	...	O_{2n}
A_3	O_{31}	O_{32}	O_{33}	O_{34}	...	O_{3n}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$		$\vdots$
A_m	O_{m1}	O_{m2}	O_{m3}	O_{m4}	...	O_{mn}

O_{ij} = OUTCOMES

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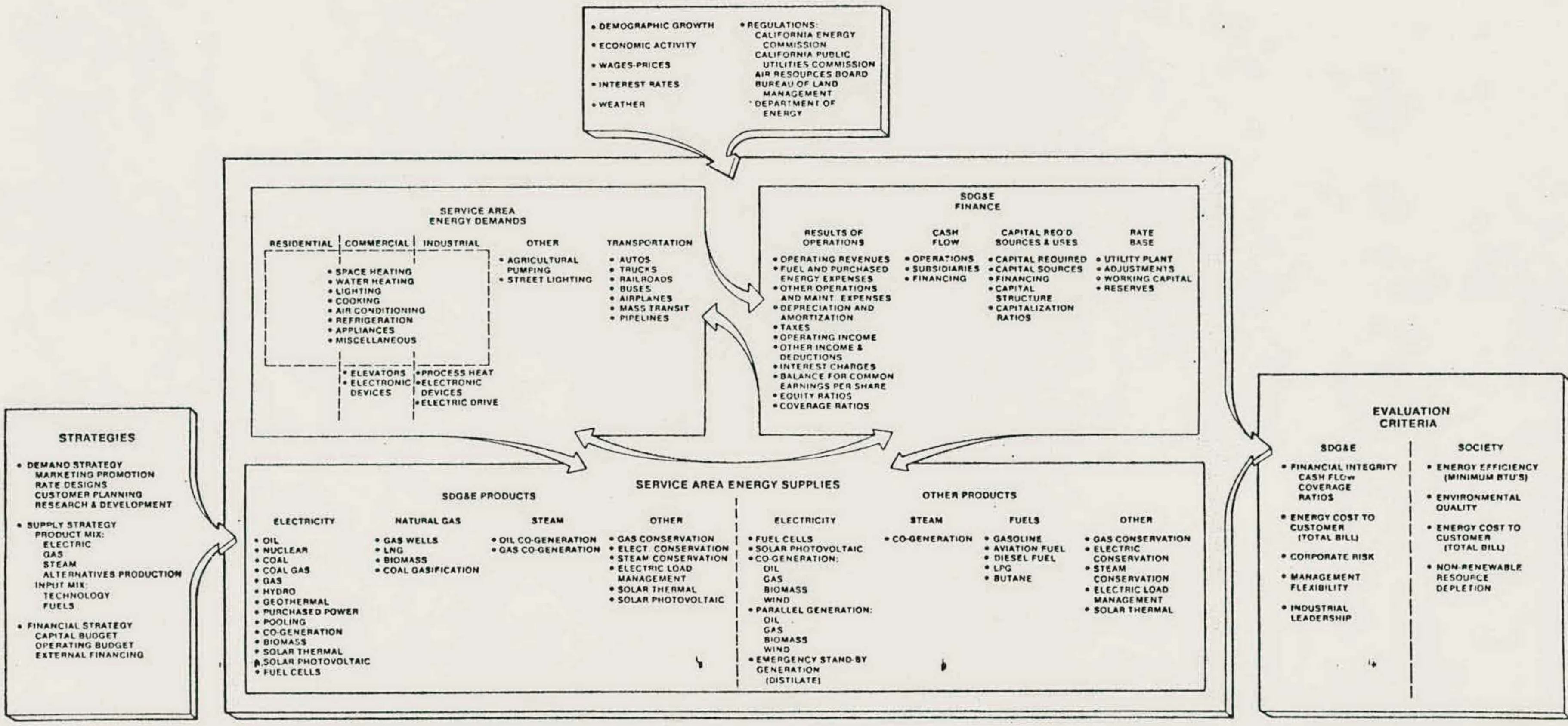
Slide 3

STRATEGIC PLANNING AND RISK ANALYSIS FRAMEWORK



PLANNING

ALTERNATE ENERGY STUDIES IN AN INDUSTRIAL COMPLEX

Hugh D. Leenhouts
DOE/ALO

Introduction - The Speaker's Perspective

In much the same fashion as NASA's huge installation at Houston, Texas is responsible for NASA's manned space program, the Albuquerque Operations Office of the Department of Energy, is the "Program Office," the "Technology Center," the "hub" (if you will) of the nation's nuclear weapons research and development and production activity. We do all of the R&D by contract at such Government-owned laboratories as the Los Alamos Scientific Laboratory at Los Alamos, New Mexico, and the Sandia Laboratories at Albuquerque, New Mexico. The production of nuclear weapons is carried out at other Government-owned plants located in Florida, Tennessee, South Carolina, Ohio, Missouri, Colorado, and Texas. Our "complex" consists of over 30,000 contractor employees located in 15 million square feet of facilities whose book value is almost $2 billion. Our annual operating budget exceeds $1 billion.

We joined the Department of Energy (DOE) when it was formed in 1977 by way of the Energy Research and Development Administration (ERDA) which, in turn, we joined in 1975 when the Atomic Energy Commission was merged with several other Governmental organizations to form ERDA.

Although these weapons activities are our principal responsibility, the technical capability, scientific resources, and contracting expertise built up over the years under AEC have proven to be extremely valuable to the nation as it turns to addressing the scientific and technological problems of new energy sources. In the energy R&D area, we at Albuquerque are responsible for over $200 million of annual expenditures.

I have given you this brief over-sight into the responsibilities of my office so that you will better understand where I am "coming from" in my comments as a DOE official. That is, I do not represent "Washington" as most of you might visualize that group of policy-makers or program planners and managers. Rather, I represent a group of "bureaucrats" that most of you may not have been aware existed. We operate very much like the corporate headquarters of a company with nation-wide facilities. As such, we are worried about production schedules and about running production plants and running them efficiently. As public servants, we have the additional responsibility to conduct these industrial activities as pacemakers for the rest of the country in terms of energy conservation and in attempting to find alternate fuels so as not to deplete the depletable fossil fuel inventory.

We are also, as I mentioned, directly involved with the energy R&D. That is, we erect the facilities, negotiate the contracts, interact as team members in the research strategy, and report to Washington on the progress of the programs assigned to us. Thus, we are attuned to the new energy technologies and are anxious to have each of them be given every chance to be proven-out.

In short, we are shirt-sleeved, product-oriented organization; and, I would like to talk with you today from that perspective.

Need for Federal Facilities to Lead the Way

As part of the Federal establishment, we have felt a special obligation, since the early 1970's, to lead the way in instituting energy-saving techniques and in investigating new ways of operating which will save oil and gas. Every one of our plants and laboratories utilizes natural gas as its primary on-site energy source and has an oil-fired backup capability. So, you might say that when we started out to look at schemes for alternate energy sources, so as to get off of gas and oil, the only way we could go was "up."

At our seven sites, we consume the equivalent of 1.5 million barrels of oil a year. That is, I am told, about the equivalent of the total energy requirements for a community of some 25,000 persons. As a major energy-eater within the Department of Energy (and most of it natural gas) we have felt a special responsibility to live up to the DOE's internally-imposed goal which required us to reduce our consumption of natural gas by 50% by no later than 1985 and to be entirely off of it by the year 1990. That would be one kind of problem if we were mainly an agency composed of office workers. It is quite a different problem when you are operating production plants, laboratories, and remote test stations, most of which have extremely high reliability standards. It is also a timing problem. When one considers the time required: to do preliminary planning and detailed engineering; to obtain Congressional authorization and funding; and to construct plants which use fuels other than oil and gas, you can see that the year 1985 (to be half-"de-gassed") is almost upon me.

Incidentally, the requirement to be 100% off of natural gas by 1990 was picked up and incorporated into Public Law 95-620, "Power Plant and Industrial Fuel Use Act of 1978."

When Mr. O'Leary spoke at Albuquerque one year ago to the Second National Conference on Evolution of Technology for Energy Conservation, he made the point that one of the principal roles of DOE is to begin to restore some of the Nation's energy options. He also included strong comments with regard to the need for conservation and some very specific remarks with regard to converting utilities to coal as the primary fuel.

With regard to conversion to coal, he noted that, up to that time, the Government had not been at all successful in getting utilities to get off of oil or gas and back to coal. In fact, none had switched back. As most of you know, the "Power Plant and Industrial Fuel Use Act of 1978," which is part of the National Energy Act passed by

Congress last Fall, was, in part, aimed at stimulating the switch to coal and other alternate fuels. While we tend to think of the Act as being designed to reinforce the interest in switching to coal and alternate fuels in the utility industry, the industrial sector would also be "persuaded" to switch by a variety of means. Another Bill, which is also part of the National Energy Act, deals with the regulatory policies affecting public utilities. One of the objectives of that Bill was to favor industrial cogeneration. The Act provides for a variety of activities which will lead to greater realization of the Nation's potential for recovering and using waste heat energy through cogeneration (that is, the simultaneous production of process steam and electricity).

The studies which I would like to discuss are real-life examples of our efforts, both to switch to alternate fuels and to maximize the benefits of cogeneration. The studies also fit neatly into Mr. O'Leary's vision of DOE being the leader in exploring other energy options--all the while also championing conservation.

Conservation

First, with regard to conservation. In 1976, we selected a Nationally-recognized engineering firm to make in-depth analyses of each of our sites' operations and the ways in which they consume energy.

Some of the facilities were constructed during World War II. Others have been built-up over the years through a long series of annual appropriations to construct individual buildings, each separate from all others. All of them have extremely high requirements for temperature and humidity control. So-called "clean rooms" and "super-clean rooms" (where atmospheric and particulate controls are carried to the extremes of present technology) are a common-place. Once-through ventilation is the norm.

The resultant reports were real eye-openers as to the energy-saving opportunities. They have led to a long series of both short-term energy-saving steps and more expensive, elaborate, long-term projects. Funding restraints being what they are, we have a ready-made laundry list of yet-to-be funded projects that will take us into the early 1980's. The total price tag is $21 million.

Although we are, thus, nowhere completed with this program, it has already paid substantial dividends. So much so that, even though the scope of our operation has grown consistently, our energy consumption has not. If we are able to complete our program on schedule, we estimate accumulated savings in our energy bill of over 1/4 billion dollars by the year 1995. Not a bad return on a $21 million investment.

Mr. Wayne Johnson, Deputy Director of our Facilities and Construction Management Division and a prime-mover in this work is also at this conference. We would be happy to talk with you about this program and to share some of our technical reports if that seems useful to you.

Alternate Energy Studies

Turning now to the subject of converting to alternate energy sources, I would like to describe the program we initiated some two years ago.

Again, we employed nationally-recognized consultants (major A-E firms) to analyse our seven sites. This time, we hired several different firms. We went to several companies both to save time and so as to be sure we would have a good look at all possible technologies, not just the "pet idea" of one firm. These studies are now complete; and at five of the seven sites, cogeneration of electricity has been recommended. In every case, coal won-out as the fuel. Budget data sheets are in the process of being prepared.

The criteria that we gave the consultants at the start of each of the studies were, first, to explore all viable technical options for producing process heat and, then, to narrow down to those options which would assure a reduction of natural gas use to 50% in 1985 (of what we have been consuming in 1975) and to eliminate the use of natural gas as a fuel by the year 1990. It was our intention to support the exploration of a full flow of options and to require that each of these be given an adequate evaluation. Some of the options, however, were dismissed very early as being too unreliable or unproven to be considered for plants with such critical energy needs as ours.

As a matter of fact, our concern for the reliability of the new, or alternate, technology forces us into the dilemma that, as active participants in the new energy R&D programs, we would dearly love to do a real-live "demonstration" project; but, as responsible landlords with the additional responsibility of producing nuclear weapons to extreme quality standards and to high-priority production schedules, we must opt for the conservative, proven technology. The list of options or sub-options we considered includes:

- Waste Heat
- Wind
- Hydraulics
- Geothermal
- Wood
- Nuclear
- Solar
- Solid Waste
- Refuse-derived-fuel (RDF)
- Total Electric

- Heat Pumps
- Hydrogen Fuel Cells
- Coal
  - Conventional
  - With cogeneration
  - Gasification
  - With Solid Waste or RDF
- Fluidized Bed

I would like to discuss a few of them in the next few minutes, as they applied to our particular situation.

Each of our consultants studied in some depth the use of refuse as a fuel in one form or another; and each discarded the concept as not being applicable as a direct-burning fuel. For example, to apply that process at our Kansas City Plant would require some 65 truckloads of raw garbage being delivered per day. The operational problems of trucking that much raw garbage over the city streets and the physical security problems of admitting that stream of traffic to a "physically-secure" site were a little over-powering to us. However, we would have considered using the pelletized fuel (derived from refuse) if a central processing plant were available or were to be developed by the community. In this way, we could stimulate the development of that industry by providing a market for approximately one-third of the presently-available supply. We might still consider supporting that option if the City or one of the major districts were to indicate an interest in such a development. Recent studies indicate that it is cheaper to dump refuse ($3 a ton) than to process it (between $7 and $10 a ton). Without a subsidy or a high "tipping fee" from the municipality whose trash is being converted, the recovery system breaks down; and a valuable energy resource is lost.

Wind was also considered in most cases. Again, despite the active in-house R&D programs we have in the wind technology, we had to discard wind due to lack of reliability for our purposes.

Geothermal was also considered; and, in the case of Los Alamos, New Mexico, it is still a potential contender. That area is a promising geothermal resource. DOE is in partnership with Union Oil Company and the Public Service Company of New Mexico to construct a 50 megawatt demonstration plant. That plant will utilize hydro-thermal (wet) geothermal energy. In addition, the Los Alamos Scientific Laboratory has the lead role within DOE to investigate extracting heat from so-called Hot Dry Rock. That is the deeper, but more geographically dispersed heat from the earth's crust. The Hot Dry Rock program is presently undergoing some unique developments in Los Alamos. If it were possible for us to delay making a final decision for a few years, we would consider waiting until that technology has either developed into a reliable resource or been proven unworkable, at least, at Los Alamos.

One rather unique concept kept popping up during our studies. This idea was attractive to some people because it would accomplish the objective of getting an individual plant off of natural gas and oil and it could be accomplished in less than two years. The idea was to replace the central steam plant with an electric/steam boiler. Simple solution? I'm sure the electric utilities would agree and applaud that idea. The initial cost would be about one-tenth of the coal alternatives ($6 million vs $67 million). So much for the good news. The bad news? The life-cycle costs would go from $161 million to $212 million over the life of the coal alternative. Further, the use of raw fuel would almost double. We had problems with that approach, not only for those reasons; but also because this solution merely transferred the problem from us to the utility; and it might even increase the use of natural gas or oil, depending upon the supply situation of the utility. The only logic to this alternative might be as a very temporary measure where real shortages of oil and natural gas exist and the utility has a coal or nuclear base or where it was advisable to delay a decision until a new technology comes on-line.

Nuclear energy was considered at some locations and eliminated early in all of the studies except at Los Alamos. Our consultant did some additional effort on a nuclear concept called a pebble bed reactor which is being developed in Germany for district heating. It is uncertain what value European experience with pebble bed reactors would be to us with respect to licensing within the U.S. Another problem which would have to be overcome is fuel fabrication since there are no facilities available for this effort at present. These obstacles, which may prohibit its ever being acceptable, certainly would delay its use to an undetermined timeframe. Our consultant found that the initial cost of this concept is excessively high by comparison to the others. However, due to its lower fuel cost and long life, the pebble bed concept does offer a low annualized cost. In fact, it was the lowest annualized cost of any of the concepts considered at the Los Alamos Site. In any case, for our purposes, we decided that it is not being feasible to consider as a resolution to our immediate problem.

Considerable effort was expended in the evaluation of the available forms of solar technology. For example, one consultant evaluated what the cost might be, in gross terms in using the so-called "power tower" concept. In its simplest terms, a power tower is a boiler perched on top of a tall structure (tower) with a field of mirrors surrounding it which focus the sun's rays on the boiler and, thus, produces steam. We have recently completed a 5 MW test facility at Albuquerque; and a "second-generation" plant under construction at Barstow, California, is designed to produce 50MW. According to the consultant's estimate, the unit cost of useful energy, compared to that from a conventional plant (coal fired plant) would cost something in the neighborhood of 19 times as much as the conventional coal fired plant. So, we also abandoned that concept as not being technologically ready for our use at this time. Other forms of solar, of course, are not as bad, cost wise; and we have indicated that, in all cases, we will utilize as much direct solar as can possibly be included in new construction. (We have found that solar is penalized much less if you are able to integrate it into new construction than if you attempt to retrofit existing facilities.) Our plan is to support some 35% solar in all new construction for the most feasible concepts to reduce raw energy use, to stimulate the solar industry, and to demonstrate the federal commitment to this alternate energy option.

We were, thus, both surprised and more than a little disappointed that, in every case, the final solution for the near-term resolution of our requirement to convert to an alternate fuel turns out to be coal. That was the decision of five separate engineering firms each independently reviewing the available technologies. As a matter of fact, we discovered in our studies that no "new" technology, that is none of the emerging technologies, would survive at the present time compared to coal on a life-cycle analysis. We did find, however, that the use of a substitution of coal in all cases required us to replace the total central plant. None of these plants could be converted directly to the use of coal. Thus, we are faced with a monstrous construction price-tag and building program if we are to implement the program. We also discovered that, compared to the continued use of gas or oil for fuel, and considering the present investment as sunk, converting to coal is cost-effective over a period of 17 to 18 years. The initial investment would be recovered with interest. In other words, if we continue to use gas and oil as fuels, we will have expended the same number of dollars over the next 17 to 18 year period than if we make the decision to convert to coal and build new coal-burning plants.

Cogeneration

We also discovered a very interesting phenomenon in the consideration of cogeneration at five of the sites. We found that, if we use "selective" generation, we add $4-5 million dollars to the initial investment over the cost of a conventional coal-fired plant without cogeneration. By "selective" generation, we mean passing high pressure steam through a turbine to generate electricity with the heat that would otherwise be wasted. The selective approach produces only a portion of the electrical load of the facility and that portion is totally dependent upon the amount of process heat which the facility happens to be producing at that time for its other needs. Despite these higher costs ($4 to 5 million) we discovered two important facts: first, that the initial capital will be recovered, with interest, through savings over the 25-year life of the equipment. (Thus, the use of cogeneration, from an economic point of view, is a standoff.) Second, and of great interest to us, we discovered enormous savings in raw fuel as a result of cogeneration. (This is because of the improved efficiency of fuel utilization.)

Of course, we have to keep in mind that those fuel savings occur back at the public utility's plant--not our plant. As a matter of fact, we have to burn a little more coal under cogeneration. To give you one example, in the case of our Sandia Laboratories in Albuquerque, we found that a coal-fired station with cogeneration would consume slightly less than 1.2 million BTUs X 10^6. A straight coal-burning plant would consume slightly less than 1 million BTUs X 10^6. On the other hand, our need for public utility-supplied electricity would drop from over 1.7 million BTUs X 10^6 to 1.3 million BTUs X 10^6. A net savings in raw fuel utilization of some 225 billion BTUs.

In general, we found that this concept would reduce the use of raw fuel by more than 50% for the approximately 5-7 megawatts of electrical power that we could generate at each of our plants. That is to say, the heat rate for production of electricity on-site would require approximately 4 to 5 thousand BTUs/kilowatt hour compared to 10 to 12 thousand BTUs/kilowatt hour if produced off-site by the serving utility. That is to say, that there is about a 2 to 1 relationship between the two methods.

Due to the profile of our steam requirement for heating and plant production processes, we found that we only are able to generate approximately one-fourth of our total electrical requirements.

As with the case of our comprehensive energy-conservation studies, these alternate energy studies are in formal report form; and we would be pleased to share the information with any of you who may be interested. Again, please see either me or Mr. Johnson.

Conclusion

In conclusion, let me say that we are moving forward with an aggressive program for conservation and conversion to the more abundant types of fuel. We see ourselves in the rather unique position of, not only representing the Energy agency, but more importantly, having a foot also planted firmly in the industrial world. We, thus, believe that we may have something special to offer in the way of information and, hopefully, expertise in this area. We hope to be able to exchange that information with all government agencies, and hopefully, with the industrial consumer, as well.

One thing that you should keep in mind in what I have said about cogeneration is that the National Energy Act includes an incentive, an investment credit for cogeneration that we did not include in our studies. (We weren't sure how the Government would give itself an investment credit.) That credit would, however, be a "plus" to you in your economics. There is a potential of receiving as much as 20% of prepaid tax on investment credit if you are an industrial customer. Even without that, our own studies indicated that there is a cost benefit to us in doing the cogeneration. Accordingly, we believe that, given the proper cooperation between industrial plants, which could utilize energy in the form of processed steam, and the utilities that serve them, there would be a great potential for saving fossil fuel and, as Mr. O'Leary said, "finding ways to do more with less."

Thank you very much.

ALTERNATIVE SYSTEMS CONSIDERED

LOCATION

ALTERNATIVE SYSTEMS	LOS ALAMOS	KANSAS CITY	DAYTON	ROCKY FLATS	SANDIA	AMARILLO	PINELLAS
WASTE HEAT		○	○			○	
WIND	○		○	○	○	○	○
HYDRAULIC			○				
GEOTHERMAL	●*		○	○	○	○	○
WOOD	○		○	○	○		○
NUCLEAR	●	○	○	○	○	○	○
SOLAR	●	○	○	○	○	○	●*
SOLID WASTE	○	●	○	○	○	○	○
REFUSE DERIVED FUEL (RDF)	○	●	○	○	○	○	○
TOTAL ELECTRIC	●	●	●	○	○	●	○
HEAT PUMPS			●	○	○	○	●*
HYDROGEN FUEL CELLS		○					
COAL — CONVENTIONAL	○	●	●	●	○	●	○
COAL — W/CO GENERATION	●*	●*	●	●*	○*	●*	
COAL GASIFICATION	●	●	○	○	○	○	○
COAL W/SOLID WASTE/RDF	○		●	●	○	○	○
COAL — FLUIDIZED BED		●*	●*				

○ - ALTERNATIVES CONSIDERED IN PHASE I

● - ALTERNATIVES CONSIDERED IN PHASE II

* - SELECTED ALTERNATIVE

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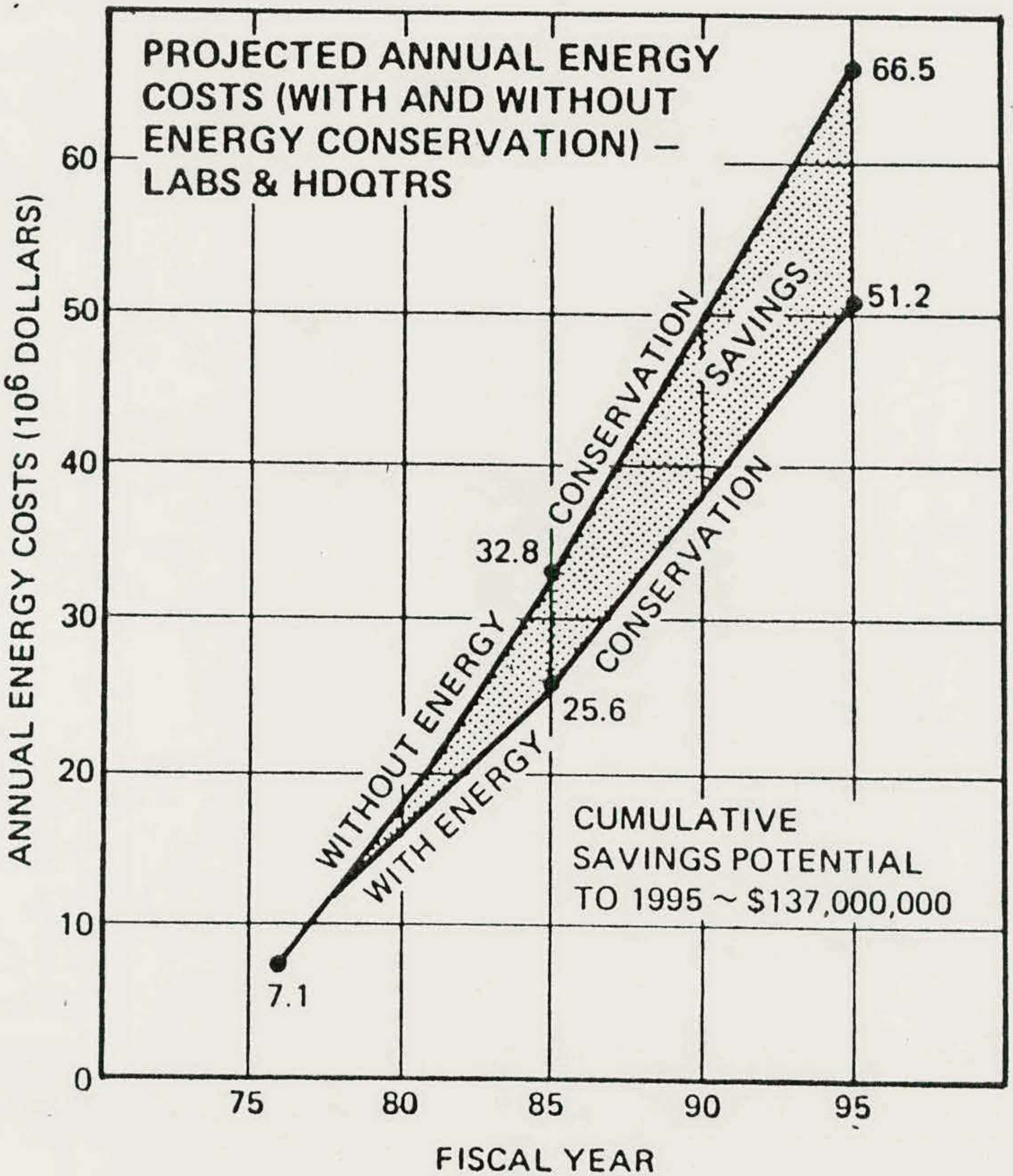

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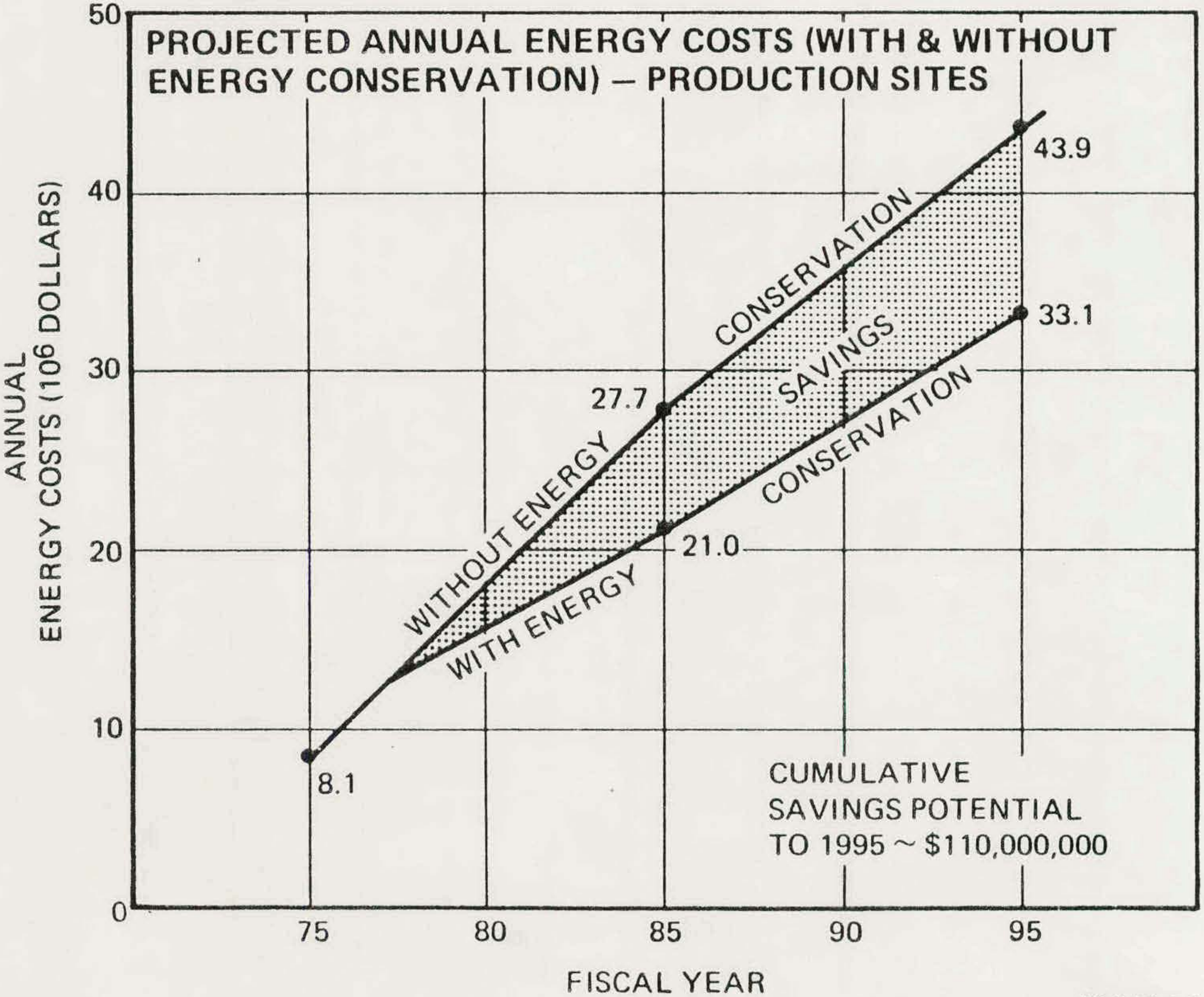

FCM Division 5/77

CONSERVATION:

ENERGY MANAGEMENT BY DESIGN

KEYNOTE ADDRESS

BY

GOVERNOR JERRY APODACA

PRESIDENT

NATIONAL ISSUES COUNCIL

MARCH 6, 1979

EL PASO CIVIC CENTER

EL PASO, TEXAS

I AM VERY PLEASED TO BE HERE TODAY TO ADDRESS THIS SYMPOSIUM....THE WISE USE OF ENERGY, AFTERALL, IS INDISPUTABLY THE NATION'S MOST PRESSING PROBLEM....AND I HAVE BECOME VERY MUCH AWARE, BOTH IN MY POSITION AS PRESIDENT OF THE NATIONAL ISSUES COUNCIL AND IN MY RECENT CAPACITY AS GOVERNOR OF A MAJOR ENERGY PRODUCING STATE, OF THE VAST IMPORTANCE THAT EFFICIENT ENERGY MANAGEMENT WILL PLAY IN THE FUTURE OF THIS COUNTRY.

I SEE BY THE ROSTER OF SPEAKERS AT THIS SYMPOSIUM THAT IT INCLUDES MANY OF THOSE WHO WILL BE PLAYING A KEY ROLE IN OUR ENERGY FUTURE. TO A GREAT EXTENT, IT WILL BE UP TO THE PUBLIC UTILITIES AND ENERGY MANAGEMENT DESIGNERS TO PLOT THE MOST PRACTICAL WAYS FOR ALL OF US TO MAKE THE BEST OF THE LIMITED SUPPLIES OF OUR ENERGY RESOURCES. I DON'T ENVY THE HEAVY RESPONSIBILITY THAT RESTS ON YOUR SHOULDERS....BUT AT LEAST THERE IS NO QUESTION IT WILL BE AN EXCITING CHALLENGE.

I WANT TO SAY AT THE OUTSET THAT I HOPE YOU HAVE ENJOYED

YOUR LUNCH BECAUSE WHAT I AM GOING TO SAY MAY NOT SIT TOO WELL WITH SOME OF YOU. I RECOGNIZE, HOWEVER, THAT THIS IS A THINK SESSION AND EVERYONE PRESENT SHOULD BE INTERESTED IN DEVELOPING NEW AND CREATIVE IDEAS, EVEN IF THEY ARE CONTROVERSIAL. REHASHING OPTIONS WILL BE YOUR TASK IN THE NEXT FEW DAYS AND, IF ANYTHING, I HOPE TO INCREASE YOUR APPETITE FOR AN OPEN DISCUSSION OF THE ISSUES. PLEASE CONSIDER THESE WORDS AS SOME THOUGHTS TO CHEW ON....I PROMISE, ANY REQUEST FOR A FULL DIGESTING PROCESS WILL BE CONFINED TO YOUR LUNCH.

THERE ARE TWO VERY IMPORTANT ENERGY CONSERVATION CONCEPTS THAT I DON'T THINK THE COUNTRY---PUBLIC OR PRIVATE SECTOR---HAS GRASPED. THE FIRST IS THAT EFFICIENT USE OF ENERGY SAVES MONEY AND RESOURCES FOR EVERYONE AND FOR THE FUTURE.....WE ARE STILL BEING MOLDED AND MOVED BY THE OUTDATED NOTION THAT ENERGY IS CHEAP AND AVAILABLE FOR ANY PURPOSE....AND WE HAVE A LONG WAY TO GO BEFORE THERE IS RECOGNITION OF THE TRUE VALUE OF ENERGY RESOURCES.

THE SECOND CONCEPT IS THE AWARENESS THAT DECISIONS FOR PRIORITIES IN ENERGY USE MUST BE JOINTLY UNDERSTOOD AND MADE BY

THE PRODUCER AND CONSUMER. WE CANNOT CONTINUE TO FUNCTION WITH OUR DEMOCRATIC TRADITIONS OF FREE CHOICE UNLESS ALL SEGMENTS OF SOCIETY PARTICIPATE IN DECISIONS OF EFFICIENT ENERGY USE. THAT MEANS SHARING IN THE NECESSARY PROCESS OF DECIDING THE PRIORITIES FOR ENERGY USE.

LET'S FACE IT....IN TERMS OF REAL ENERGY CONSERVATION, THE COUNTRY HAS FALLEN FLAT ON ITS FACE....WE'VE BECOME ADDICTED TO FREE AND EASY ACCESS TO ENERGY AND WE CAN'T SHAKE THE HABIT.

THE BAROMETER MEASURING OUR ENERGY "CRISIS" OVER THE PAST FIVE YEARS HAS BEEN THE GROWING DEPENDENCE ON FOREIGN OIL. WE HAVE TO RELY ON IMPORTS FOR OVER 40 PERCENT OF OUR DAILY OIL CONSUMPTION....AND THAT QUOTA THREATENS TO INCREASE TO OVER 50 PERCENT BY 1985.

THE RECENT DISCOVERY OF OIL IN MEXICO ADDS TO WORLD SUPPLIES....BUT OUR POSTURE IN YEAR'S PAST DOESN'T PUT US IN THE DRIVER'S SEAT. AS A FRIENDLY NEIGHBOR, OUR TRADE AGREEMENTS SHOULD HAVE BEEN AUTOMATIC....INSTEAD WE HAVE NOT TAKEN MEXICO AND OTHER DEVELOPING COUNTRIES SERIOUSLY, REGARDING THEM ONLY AS A PLACE TO VACATION AND EXPLOIT. NOW WE'RE GOING TO SUFFER

FOR THE LACK OF RESPECTABLE RELATIONS.

NOW, ALSO, THE DRAMATIC CHANGE OF EVENTS IN IRAN PROMISES TO RESTRICT OUR SUPPLIES TO AN EVEN MORE DANGEROUS DEGREE.

THIS RELIANCE POSES A CONSIDERABLE THREAT TO OUR ECONOMY. ....ESPECIALLY WHEN THE NATION RELIES ON OIL AND GAS FOR OVER 75 PERCENT OF ITS ENERGY NEEDS. AND FOR STATES LIKE TEXAS, THE RELIANCE IS EVEN GREATER SINCE THIS STATE HAS DEPENDED ON OIL AND GAS FOR OVER 95 PERCENT OF ITS ENERGY.

DESPITE RECOGNITION OF THE DANGERS OF THIS DEPENDENCE, THE NATION CONSUMED 10 PERCENT MORE ENERGY DURING THE FIRST QUARTER OF 1978 THAN THE LAST QUARTER OF 1977....PRODUCED 9 PERCENT LESS ENERGY....AND IMPORTED 5 PERCENT MORE ENERGY. THE SECOND QUARTER OF 1978 GAVE A HEALTHIER PICTURE IN TERMS OF INCREASED DOMESTIC PRODUCTION AND DECREASED CONSUMPTION AND IMPORTS, BUT THE CONDITION OF DEMAND EXCEEDING SUPPLY STILL EXISTS.

EXPERTS SAY THAT DOMESTIC OIL AND GAS SUPPLIES HAVE BEEN STEADILY DECLINING AT ABOUT 6 PERCENT A YEAR....AND IT IS ESTIMATED THAT THESE RESOURCES WILL BE LARGELY DEPLETED BY THE

TURN OF THE CENTURY. ALTHOUGH WE MAY BE ABLE TO PRODUCE MORE DOMESTICALLY AND DIMINISH THE NEED TO IMPORT RESOURCES, WE WILL STILL SEE OUR RESOURCES BE DRASTICALLY REDUCED IF WE KEEP UP THE PACE OF ENERGY CONSUMPTION.

EVEN THIS "IMPORT BAROMETER" FAILS TO GAUGE THE SEVERITY OF THE PROBLEM....BECAUSE EVEN IF WE PUT SOME BREAKS ON OUR RATE OF CONSUMPTION, OTHER INDUSTRIALIZED NATIONS ARE CONTINUING TO INCREASE THEIR CONSUMPTION....AND THE CURRENT HIGH RATES OF FOSSIL FUEL CONSUMPTION IN DEVELOPED COUNTRIES WILL REDUCE THE AVAILABILITY OF THESE RESOURCES FOR THIRD WORLD COUNTRIES. IN ADDITION TO THE MORAL CONSIDERATION OF DENYING THOSE COUNTRIES ACCESS TO FOSSIL FUELS, THERE IS THE THREAT THEY WILL USE OTHER VALUABLE RESOURCES AS LEVERAGE TO DEMAND A GREATER SHARE OF EXISTING WORLD SUPPLIES OF FOSSIL FUELS. SUCH TRADEOFFS WOULD ACT TO COMPOUND THE BIND PUT ON THE U.S. BY DEPENDENCE ON OIL IMPORTS.

I, MYSELF, DON'T THINK THE THIRD WORLD'S CRITICISM OF THE GREED OF DEVELOPED COUNTRIES IS UNJUSTIFIED. HERE WE ARE---
A NATION RICH IN NATURAL RESOURCES, HIGHLY ADVANCED IN OUR

TECHNOLOGY AND SKILLS---HAVING TO REQUIRE OVER 35 PERCENT OF THE WORLD'S RESOURCES FOR LESS THAN 6 PERCENT OF THE WORLD'S POPULATION....I DON'T THINK THAT'S AN ACHIEVEMENT TO BE PROUD OF ....AND I THINK WE HAVE THE POTENTIAL, PROVIDED WE HAVE THE COMMITMENT, TO LIVE WITHIN REASONABLE BOUNDARIES OF ENERGY CONSUMPTION WITHOUT DRAMATICALLY CHANGING THE WAY WE LIVE.

THERE HAS BEEN A TENDENCY FOR SOME TO CONSIDER ENERGY CONSERVATION AS BEING SYNONYMOUS WITH ECONOMIC DECLINE.... I THINK THAT ATTITUDE AMOUNTS TO A FAILURE TO UNDERSTAND A BASIC PRINCIPLE OF ENERGY EFFICIENCY. AND, IN FACT, I BELIEVE THE OPPOSITE IS TRUE....THAT EFFICIENT USE OF ENERGY CAN BRING ABOUT HEALTHIER ECONOMIC CONDITIONS IF IT IS REGARDED AS REDUCING WASTE AND IMPROVING EFFICIENCY IN THE PRODUCTION AND END-USE OF ENERGY.

SOME HAVE THE ATTITUDE THAT ENERGY CONSERVATION ISN'T GOOD FOR BUSINESS....THAT IF WE CAN'T USE OUR ENERGY RESOURCES WITH COMPLETE FREEDOM, WE ARE HURTING THE ECONOMY....I SUSPECT THAT UNDERLYING SOME PUBLIC UTILITY DECISIONS BEATS THE RELUCTANT HEARTS OF SOME WHO SECRETLY FEEL THAT CONSERVATION WILL SPELL A DRASTIC DECLINE FOR THE ECONOMY....OTHERS MAY FEEL THAT ENERGY

CONSERVATION WILL HAVE A NEGATIVE IMPACT ON EMPLOYMENT....OR STILL OTHERS MAY SEE CONSERVATION AS ONLY A TEMPORARY EXPEDIENT UNTIL NEW ENERGY ALTERNATIVES BECOME AVAILABLE.

I THINK THESE ATTITUDES CONFUSE ENERGY CONSERVATION WITH LOSS OF PRODUCTION. SCIENTISTS TELL ME ENERGY IS NEVER LOST OR FULLY CONSUMED....THOUGH IT MAY BE CONVERTED INTO HIGHER OR LOWER LEVELS AND MAY PRODUCE AN UNWANTED BYPRODUCT SUCH AS DIRTY AIR OR BAD WATER. SO WE SHOULD THINK OF CONSERVATION AS PROPER USE OF ENERGY AS IT IS TRANSFORMED FROM ONE FORM TO ANOTHER....WE SHOULD THINK OF POLLUTION AS AN ENERGY COST WHEN CONSIDERING THE NEED FOR NEW GENERATING CAPACITY....WE SHOULD THINK OF CONSERVATION ---REGARDED AS IMPROVED EFFICIENCY---AS A PRACTICAL PRINCIPLE OF DESIGN FOR FUTURE USE OF ANY ENERGY SOURCE AND NOT JUST FOR THE SHORT TERM.

INSTEAD OF REGARDING CONSERVATION AS A LOSS OR REDUCTION OF OUTPUT, WE SHOULD CONSIDER IT AS MORE MILEAGE OUT OF LESS ENERGY. IN THAT SENSE, WE DERIVE MORE RATHER THAN LESS BENEFIT FROM EFFICIENT ENERGY USE AND IMPROVED COMFORT AND A HIGHER QUALITY OF

LIFE RATHER THAN SACRIFICES.

AN IRANIAN---OF ALL PEOPLE---ONCE TOLD ME THAT HE DIDN'T THINK GOD MEANT US TO BURN OIL....THAT WE SHOULD SAVE IT FOR OTHER THINGS.

TRADITIONAL ENERGY CONSERVATION CONCEPTS HAVE LARGELY FOCUSED ON THE CONSUMER. ENERGY OFFICIALS HAVE BEEN TELLING BUSINESS AND RESIDENTIAL CONSUMERS THAT THEY CAN SAVE MONEY ON THEIR UTILITY BILLS BY VOLUNTARILY IMPLEMENTING ENERGY SAVING MEASURES.

A CERTAIN AMOUNT OF PROGRESS HAS BEEN MADE IN PROGRAMS SUCH AS WEATHERIZATION AND APPLIANCE EFFICIENCY....BUT OVERALL CONSUMPTION RATE FIGURES SHOW THAT PROGRESS HAS BEEN SLOW.... AND I THINK THERE ARE BASICALLY THREE MAIN REASONS WHY THIS IS THE CASE....

THE FIRST IS THAT GOVERNMENT DECISIONS AND UTILITY PRACTICES HAVE BEEN SLOW IN BACKING UP THESE VOLUNTARY ACTIONS WITH ECONOMIC INCENTIVES. SOME OF THIS FAILURE IS DUE TO THE SLUGGISHNESS OF CONGRESS TO BACK A NATIONAL ENERGY PLAN....SOME IS DUE TO BUREAUCRATIC REDTAPE....AND SOME SIMPLY TO A WEAK

COMMITMENT TO TRUE ENERGY CONSERVATION.

WE CAN'T EXPECT BUSINESS PEOPLE OR HOMEOWNERS TO PUT TOO MUCH STOCK IN A NATIONAL CONSERVATION EFFORT WHEN THEY ADOPT CONSERVATION MEASURES AND THEN SEE THEIR UTILITY RATES CONTINUE TO RISE AND THE PROMISED TAX INCENTIVES FAIL TO MATERIALIZE.

THE SECOND REASON FOR POOR PROGRESS IS THAT THE BRUNT OF PLANS, ASSISTANCE AND INCENTIVES FOR ENERGY CONSERVATION HAVE BEEN CONFINED TO A FEW SECTORS OF THE ECONOMY. TRANSPORTATION, FOR EXAMPLE, IS ONE OF THE MAJOR ENERGY USERS IN THE NATION....YET THERE IS NO RECOGNIZABLE CONSERVATION PLAN AT THE NATIONAL LEVEL THAT WOULD BRING ABOUT ANY SIGNIFICANT ENERGY EFFICIENCY.

ENERGY MAY BE THE HOTTEST ISSUE TODAY....BUT WE DON'T EVEN CONSIDER WHAT MAKES UP COMPLETE ENERGY USE. ENERGY COSTS OF TRANSPORTATION OR HEATING A BUILDING OR USING AN APPLIANCE ARE COMMONLY USED WITHOUT CONSIDERING THE COSTS OF BUILDING A CAR OR CONSTRUCTING A BUILDING OR MANUFACTURING THE APPLIANCE....AND IF ENERGY MANAGERS AND PLANNERS DON'T SPEAK PUBLICLY IN THOSE TERMS, THEN CONSUMERS ARE CERTAINLY NOT GOING TO MAKE THEIR ENERGY PURCHASES IN THOSE TERMS.

THE THIRD MAJOR REASON FOR LACK OF PROGRESS IN CONSERVATIOI. IS THE FAILURE TO SET PRIORITIES OF ENERGY USE AND TO MATCH FUEL SOURCES WITH APPROPRIATE USES. WE'RE GOING AHEAD WITH INCREASED GENERATING CAPACITY WITHOUT CONSIDERING WHERE THE ENERGY IS GOING. NECESSITIES SUFFER ALONG WITH WASTEFUL CONVENIENCES IN THE CHAOS OF CONSUMING EVERY GOOD OR SERVICE MADE AVAILABLE BECAUSE OF CHEAP ENERGY.

....BUT WE CAN DO SOMETHING ABOUT SUCH WASTEFUL PRACTICES IN THE FUTURE.

MUCH OF THE TRANSITION TO EFFICIENT ENERGY USE CAN COME THROUGH A CHANGE IN TECHNOLOGY. THIS IS NOT TO SUGGEST WE SCRAP TECHNOLOGY....ONLY THAT WE ADAPT TO MORE EFFICIENT ENERGY PRACTICES.

IT MIGHT BE INTERESTING TO SOME OF YOU HERE THAT A 1977 FEDERAL REPORT RANKED ELECTRIC UTILITIES SECOND AND GAS UTILITIES THIRD IN IMPORTANCE IN THE LIKELIHOOD THAT A CHANGE IN TECHNOLOGY WOULD SIGNIFICANTLY AFFECT TOTAL U.S. ENERGY CONSUMPTION.... THAT SHOULD MEAN A LOT OF WORK FOR THE ENERGY MANAGEMENT DESIGNERS GATHERED HERE FOR THIS SYMPOSIUM.

I THINK WHAT WE'RE REALLY TALKING ABOUT HERE IS A REORDERING OF OUR THINKING ABOUT THE VALUE OF ENERGY....PERHAPS EVEN AN OVERHAUL OF OUR ECONOMIC VALUES IN TERMS OF THE RESOURCES THAT KEEP THIS SOCIETY MOVING FROM ONE DAY TO THE NEXT.

MAYBE IT BOILS DOWN TO DECIDING WHETHER WE WANT TO CONTINUE WITH A CAREFREE APPLICATION OF ENERGY....WITH A THROW-AWAY SOCIETY ....WITH DEMAND CONTINUING TO EXCEED SUPPLY UNTIL THE POINT WHERE FORCED SHORTAGES TAKE A MUCH GREATER TOLL THAN THEY DO NOW.... OR WHETHER WE WANT TO STOP AND CONSIDER EFFICIENT ENERGY USE AS A BETTER ECONOMIC INVESTMENT.

WHEN YOU THINK ABOUT IT, WE REALLY HAVE NO CHOICE IN THE LONG RUN....BUT THE LONGER WE DELAY, THE MORE SERIOUS THE ECONOMIC CONSEQUENCES....PERHAPS TO THE POINT WHERE OUR WHOLE ECONOMIC SYSTEM IS IN JEOPARDY....BECAUSE IF WE DON'T SET ENERGY PRIORITIES NOW, FORCED CURTAILMENT OF ENERGY USE MAY BE SUCH A DISTURBING SHOCK OF SUCH MAGNITUDE THAT THE ECONOMY MAY NOT RECOVER.... AND THE RESULT MAY BE THE LOSS OF MANY OF THE ECONOMIC FREEDOMS WE KNOW TODAY IN AN EFFORT JUST TO MEET OUR SURVIVAL NEEDS. IF THERE ARE THOSE THAT THINK THAT WISE ENERGY USE NOW WILL RESTRICT

FREEDOMS, CONSIDER WHAT WILL TAKE PLACE UNDER FORCED CURTAILMENTS.

I DON'T THINK THERE'S ANY DOUBT THAT IF WE HAVE A SITUATION WHERE DEMAND EXCEEDS SUPPLY, THAT SOME OF THE DEMAND HAS TO SUFFER. ....IT'S NOT A QUESTION OF WHETHER OR NOT TO SET ENERGY PRIORITIES. ....IT'S A QUESTION OF HOW TO SET PRIORITIES AND WHERE TO SET PRIORITIES.

THE MATTER OF WHERE TO SET PRIORITIES IS PROBABLY THE MOST TROUBLESOME TASK....WHICH IS WHY WE SHOULD GET DOWN TO THE BUSINESS OF DOING SO WITHOUT DELAY. AND WE CAN START WITH THE ASSUMPTION THAT WE HAVE TO CURB DEMAND, WHETHER AT THE BURNER-TIP OR THE END USER OR AT THE MANUFACTURING END THROUGH THE PRICE OF THE RAW MATERIAL. I SUSPECT WE WILL HAVE TO COVER ALL OF THE AREAS WHERE ENERGY IS LEAKING OUT WASTEFULLY TO HAVE A MEANINGFUL IMPACT.

FRANKLY, I THINK THE TIME HAS COME TO WEIGH AND COMPARE THE BENEFITS OF ENERGY CHOICES BEFORE THEY REACH THE CONSUMER. WE HAVE TO SELL THE IDEA OF ENERGY CONSERVATION AS WE WOULD SELL TOOTHPASTE OR BATH SOAP....AS A CONSCIOUS DAILY EXERCISE.

MAKING ENERGY CHOICES BEFORE PRODUCTION PROBABLY BEGINS WITH PUTTING A REALISTIC PRICE ON OUR NATURAL RESOURCES....SOONER

OR LATER SOME VALUE JUDGMENT HAS TO BE MADE ON THE EMPLOYMENT OF ENERGY RESOURCES....AND GIVEN THE RIGHT FORMAT AND VEHICLE FOR PRODUCERS AND CONSUMERS, I THINK A PROCEDURE CAN BE ESTABLISHED TO MAKE VALUE JUDGMENTS.

PERHAPS SUCH A PROCESS WOULD EXAMINE AND WEIGH THE HIGH ENERGY COSTS OUR THROW-AWAY SOCIETY HAS PLACED ON CONVENIENCE ITEMS, ON NEEDLESS PACKAGING AND ON OTHER PROCESSES THAT USE TREMENDOUS AMOUNTS OF ENERGY BUT DO NOT CONTRIBUTE ANYTHING SUBSTANTIAL TO OUR WELL-BEING....PERHAPS IT WOULD RE-EXAMINE THE NEED FOR ALL OF THE KNICK-KNACKS AND GADGETS AND DISPOSABLE ITEMS THAT ONLY RECENTLY HAVE BEEN MADE AVAILABLE TO OUR SOCIETY BECAUSE OF CHEAP ENERGY.

AS CHAIRMAN OF THE PRESIDENT'S COUNCIL ON PHYSICAL FITNESS AND SPORTS, I CAN TELL YOU THAT PROPER EXERCISE FOR PHYSICAL FITNESS DOESN'T REQUIRE HEAVY EXPENDITURES OF ENERGY FOR EQUIPMENT. ....AND THERE ARE MANY LEISURE AND RECREATIONAL ACTIVITIES THAT ARE HEALTHY AND SATISFYING BUT DO NOT CONSUME A LOT OF ENERGY IN TERMS OF RESOURCES.

BY THE TIME AN ENERGY PRODUCT OR SERVICE REACHES THE CONSUMER, MUCH OF THE ENERGY HAS ALREADY BEEN SPENT....AND IF THERE ARE NO RECYCLING MEASURES BUILT INTO THE SYSTEM, THE RESOURCE HAS REACHED A DEAD-END THAT IS LIKELY TO GO UP INTO SMOKE AND CONTRIBUTE TO THAT TROUBLESOME POLLUTION BYPRODUCT.

ECONOMISTS TOLD US YEARS AGO THAT RECYCLING WOULD NOT ENJOY WIDESPREAD USE UNTIL THE RAW MATERIAL BECOMES SCARCE ENOUGH TO JUSTIFY IT. IN MANY CASES, THE RAW MATERIAL IS STILL READILY AVAILABLE AND AT A FAIRLY CHEAP PRICE BUT THAT DOESN'T TAKE INTO ACCOUNT THE ENERGY FACTOR.

MANY OF US FAIL TO SEE THE INTER-RELATIONSHIP OF ENERGY RESOURCES WITH OTHER RESOURCES. WE AS CONSUMERS---AND SOMETIMES WE FORGET WE ARE ALL CONSUMERS---FAIL TO SEE THAT THERE IS A HIGH ENERGY COMMITMENT AND COMPONENT OF EVERY GOOD AND SERVICE.... THAT THE TRANSFORMATION OF RESOURCES HAS ALL SORTS OF LITTLE ENERGY INTER-TIES.

ADMITTEDLY, THE CONTINUAL ENTERTAINMENT OF SUCH A CONCEPT IS VIRTUALLY IMPOSSIBLE. WE'D BE SPENDING ALL OF OUR TIME

EVALUATING THE ENERGY INPUT OF EVERYTHING WE DID OR CONSUMED. ....BUT IT WOULDN'T HURT TO REMOVE THE BLINDERS NOW AND THEN TO CONTEMPLATE THE ENERGY EXPENDITURES FOR THIS OR THAT PRODUCT OR SERVICE.

MANY ENERGY OFFICIALS ARE NOW SAYING THAT ENERGY CONSERVATION IS A MATTER OF INDIVIDUAL COMMITMENT....THAT THE PUBLIC HAS TO BE CONVINCED OF THE NEED TO CONSERVE.

I THINK THERE IS A GREAT DEAL OF TRUTH TO THIS NEED BUT I ALSO THINK IT'S A CASE OF PASSING THE BUCK. UNTIL ENERGY RESOURCES ARE DEMONSTRATED TO BE VALUABLE, THE CONSUMER WILL BE RELUCTANT TO CONSERVE IN ALL BUT A FEW NARROW AREAS THAT OFFER IMMEDIATE MONETARY REIMBURSEMENT....PEOPLE SIMPLY DON'T CONSERVE AND USE EFFICIENTLY WHAT IS NOT REGARDED AS VALUABLE.

AS ONE WHO HAS HAD HIS SHARE OF HEARING PUBLIC PLEAS AND COMPLAINTS....I THINK THE PUBLIC HAS BEEN CONFUSED BY A LACK OF COMMITMENT TO MEANINGFUL CONSERVATION. SOME FEEL THAT THE SO-CALLED "ENERGY CRISIS" IS A FRAUD AND THAT LARGE CORPORATIONS ARE MERELY HOLDING BACK SUPPLIES TO MAKE A BIGGER PROFIT....OTHERS FEEL THAT

THE TECHNOLOGY THAT GOT US TO THE MOON WILL GET US OUT OF THE "TEMPORARY" ENERGY CRISIS.

THERE IS NO QUESTION THAT WE NEED SOME DECISIONS AT THE NATIONAL LEVEL OF ENERGY DIRECTIONS, OPTIONS, TIME FRAMES AND COMMITMENTS....WE HAVE BEEN THE VICTIMS OF TOO MUCH ILL-CONCEIVED POLICY AND LEGISLATION, TOO MUCH VACILLATION, TOO MANY POLICY REVERSALS AND SWITCHBACKS AND....ABOVE ALL....TOO MUCH RHETORIC AND NOT ENOUGH ACTION.

I BELIEVE THAT PUBLIC UTILITIES ARE GOING TO HAVE TO RESTRUCTURE THEIR THINKING ABOUT THEIR ROLE IN ENERGY MANAGEMENT. ....THEY WILL HAVE TO THINK IN TERMS OF EFFICIENT ENERGY USE RATHER THAN AN UNCONDITIONAL COMMITMENT TO ENERGY SUPPLY.... THEY WILL ALSO HAVE TO RECOGNIZE THAT RISING ENERGY COSTS WILL HAVE UNEQUAL IMPACTS ON DIFFERENT SEGMENTS OF THE POPULATION.... AND THAT DIRECT ENERGY COSTS TAKE A BIGGER BITE OF THE BUDGETS OF LOW-INCOME HOUSEHOLDS.

COSTS ARE RISING FOR AMERICANS IN ALL AREAS OF THE ECONOMY. ....AND MUCH OF THIS INFLATIONARY SPIRAL IS AN INDIRECT RESULT

OF ENERGY SHORTAGES....UNFORTUNATELY, CONSUMERS OFTEN DON'T SEE THE CONNECTION.

SOMETIME IN THE FUTURE, WE MIGHT ALSO HAVE TO CONSIDER A DIFFERENCE IN PRICE OF THE RAW MATERIAL THAT GOES TO A NECESSITY ITEM AS OPPOSED TO THE SAME RAW MATERIAL THAT MIGHT BE DIRECTED TO A CONVENIENCE OR DISPOSABLE ITEM. THIS MAY BE REGARDED AS A LIMITING OF CHOICE....BUT IF WE GET TO THE POINT OF A CRUCIAL SHORTAGE OF ENERGY SOURCES, IT WOULD BE BETTER TO LIMIT OUR CHOICES WISELY THAN HAVE AN OVERALL DEVASTATING EFFECT ON THE ECONOMY.... A CONDITION WHERE EVERYONE SUFFERS.

I DON'T WANT TO PROJECT THE IMPRESSION OF A DOOMSDAY PHILOSOPHY IN TERMS OF ENERGY SUPPLIES. HOPEFULLY WE WON'T HAVE TO EXERCISE STRICT OR LIMITING PRACTICES THAT IMPINGE ON OUR ENERGY CHOICES. AND I KNOW WE FACE A BRIGHT FUTURE IN THE LONGTERM OF NEW AND EXCITING ENERGY ALTERNATIVES EVEN BEYOND SOLAR, WIND, COAL GASIFICATION, NUCLEAR AND GEOTHERMAL OPTIONS....

BUT I THINK WE SHOULD BE PREPARED FOR THE FUTURE AND PARTICULARLY FOR EMERGENCY SITUATIONS....AND DO SO IN A MANNER

THAT WILL DO THE LEAST HARM TO OUR ECONOMY AND DEMOCRATIC TRADITIONS.

....I DO KNOW, HOWEVER, THAT EFFICIENT ENERGY USE IS NOT A TEMPORARY NEED NOR A PASSING PHENOMENON. WHATEVER FUTURE ENERGY ALTERNATIVES WE ADOPT....AND IN THEIR TURN, LEAVE BEHIND ....ALL WILL REQUIRE EFFICIENT MANAGEMENT AND DESIGN.... AND YOU CAN CERTAINLY COUNT ON THE FACT YOUR WORK WON'T END WITH THIS SYMPOSIUM OR LONG AFTER IT.

WE'VE REACHED A MAJOR HISTORICAL INTERSECTION IN THE TIME FRAMES OF AVAILABLE ENERGY RESOURCES....THE ROAD BEHIND US LEFT A PLENTIFUL CHOICE OF ENERGY RESOURCES AND MEANT UNRESTRICTED GROWTH....THE ROAD AHEAD WILL REQUIRE SOME WISE DECISIONS UNPRECEDENTED IN HISTORY.

LET'S NOT HAVE TO UNDERGO A CRASH DIET....INSTEAD, LET'S CHOOSE A HEALTHY DIET AND STICK TO IT AS A DAILY ROUTINE THAT BECOMES A LIFESTYLE....

AND I WISH YOU THE BEST OF LUCK IN YOUR DIFFICULT RESPONSIBILITY.

INTRODUCTION

EARLE C. WILLIAMS

PRESIDENT
THE BDM CORPORATION

AND

PRESIDENT
THE NATIONAL COUNCIL OF PROFESSIONAL SERVICES FIRMS

I am sure you recall that the goal of Project Independence was to release our Country from the jaws of potential economic blackmail imposed by increased balance of trade deficits and to decrease our dependence on foreign energy sources. This program was established at the height of the 1973 oil embargo, and many suggested that OPEC prices would decrease by 1980. In fact, we have doubled our importation of oil since that time, and the price has steadily escalated. There seems little doubt that both the demand for and the price of oil will continue to increase at least in the short term.

Should we be concerned about the price or absolute availability of this finite resource? The United States has become the most powerful entity on the planet for a variety of reasons, not the least of which was the availability of cheap and plentiful energy. Our Country consumes greater than 1 cubic mile of oil annually. To state it another way -- if the entire population of the earth were placed in a box, and if each person weighed an average of 160 pounds, and if people were entirely oil (rather than 98 percent water), the volume of the oil in the box would be 1/5 of a cubic mile. A thought should be given to the amount of organic matter and time required to produce this resource, but undoubtedly I'm preaching to the choir. Your presence here today says that you are concerned about the price and availability of oil as well as of other energy sources.

Since the 1973 event, we have all heard many discussions of the energy crisis. Some have postulated that this is all a conspiracy of the big gas and oil companies to make larger profits. Some have proposed taxes on energy to heighten the consciousness of Americans to the crisis and to develop revenues for "socially desirable" programs currently unfunded or underfunded.

Conspiracy theories and political schemes notwithstanding, our problem of energy consumption is real and is becoming increasingly serious. I suggest, however, that as long as we can obtain gasoline at a negligible price any time we wish to, or can maintain our thermostats at any desired setting as long as we can pay the monthly bill, the problem will not be recognized by most Americans. When the "brown outs" and non-availability of petroleum products begin to impact our life style adversely in the mid-80's, we will react. I suggest that we anticipate this problem and, collectively, look for solutions. After all, technology got us into this -- can't technology get us out?

The solutions to our energy problem lie in creating more of it and in using less. For the former solution we can use a balanced combination of sources: nuclear, coal, hydroelectric, oil, gas, and new alternative technologies (solar, OTEC, wind, geothermal, etc.). Even with this approach, it has been estimated that by the year 2020 we will still be importing a major fraction (15 to 30 percent) of our energy. Our construction practices and industrial processes (compared to those of the Europeans) are very wasteful of energy. Conservation methods might make a significant market penetration if properly packaged, but we still are faced with a formidable problem.

Another sad state of affairs which is quite relevant to the supply of energy concerns the United States' nuclear energy posture. Our Country was the pioneer in the field of nuclear energy. Today, because of licensing regulations, we require 11 years to build a nuclear power plant that can be built in 4-1/4 years in Europe or Japan. This absurd situation exists primarily because of Government regulations developed as a result of pressures from environmental and anti-growth groups.

In the 20 years since the advent of the commercial nuclear power reactor, we have experienced no accidents involving public injury from nuclear radiation. In the same period, automobiles have killed over 900,000 and injured an additional 75 million people, and our response has been to debate the desirability, feasibility, and relative cost of various types of passive restraints to reduce injuries when accidents occur.

It's relatively easy to see the impact of the various regulations on both the cost and increased consumption of energy. The Environmental Protection Agency (EPA), the Federal Power Commission (FPC), and the Mine Safety Act (MESA) have served to clean up our environment and reduce certain hazards -- but at what cost? Should we risk economic ruin and profound adverse international ramifications unless absolutely necessary? The challenge facing us is to find an acceptable balance between the demands of our industrial and energy intensive society and the demands of that same society for clean air and water and for occupational safety.

Many, perhaps most of us here today are in some way in the professional services business. I include in this description those who design or recommend controls as well as those in the architectural and engineering professions. What is it that we can do for our respective customers to provide better services and to accelerate the energy conservation industry?

I suggest that we attempt to identify and remedy those situations and circumstances that are obviously energy wasteful today and that require only small to moderate capital investments in order to achieve substantial energy savings. To do this successfully requires a thorough understanding of not only the technology base from which we are working but also the economics of the situation under study. In representing a product, whether it be a new lighting concept, an environmental or industrial controller, insulation, an architectural design, or a recovery technique, we must convey to our customers an understanding of the cost savings (through tax incentives and/or in direct energy savings), the operations and maintenance experience (including such things as mean time to failure of the various components), and in some cases, the psychological benefits of a given approach.

As Americans and as professionals, we have a responsibility in this industry to drive these programs to and through implementation. We cannot just sit back and let the Federal Government do it through legislation or direct funding. That is not to say that high risk innovative approaches should not proceed under the auspices of the Government, but we are the people, collectively, who can make it happen.

We also have a responsibility to make reasonable profits while establishing this industry. By "reasonable profits" I mean a fair return on our investment and our professional efforts, but I specifically exclude from the definition the kind of windfall profits frequently associated with flim-flam activities, including the use of scare tactics, unjustifiable appeals to patriotism for selling purposes, misrepresentation, and fraud. In addition, we must police ourselves. The solar energy field alone is supporting many companies that are selling inferior equipment which will not function at all, or most certainly, not as advertised. The conscientious firms need to establish their own industry standards and flush out the hucksters. Many of you will recall what happended in the early years of the heat pump when the marketing of an unproven product to an unsuspecting public had a profound and adverse impact on the growth of that prticular technology. Only recently has that unfortunate beginning been overcome.

By making energy conservation products and services more available to more Americans on a believable basis, we can have a direct impact on the amount of foreign oil being imported and thus on our balance of trade deficit. In addition, a reasoned approach to conservation makes sense regardless of OPEC and trade balances. The collective power of the product and services areas we represent will have a significant impact on how and when energy conservation programs are implemented. Let us use that power wisely. Thank you.

RANKING ENERGY USES IN COMMERCIAL BUILDINGS

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Presented at

CONSERVATION: ENERGY MANAGEMENT BY DESIGN

EL PASO, TX

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RANKING ENERGY USES IN COMMERCIAL BUILDINGS

Ranking energy uses in commercial buildings is not very difficult and ordinarily wouldn't require the time devoted to this paper. On the other hand, a complete review of the energy conservation literature related to commercial buildings would require much longer than my time allotment. I could select just the key energy wasters and give a few examples of how some clever architect or engineer has reduced the waste, but that is the topic that each of the remaining papers will cover. I know some clever stories that I could work into a welcome to this session, but the session has already been opened. Now that you know the challenge I'm facing here, I'll try to cover what everyone has left for me.

A great deal of data has been gathered under the sponsorship of the Department of Energy, the American Institute of Architects, the Building Owners and Managers Association and countless others. There is no shortage of studies which contribute in one way or another to the list I call "a-thousand-and-one-ways to save energy in your building".

Such a list covers everything from the use of shade trees to the scheduling of maintenance crews. I'm sure that each of you is familiar with some version or other. But, in case you don't already have your favorite list, I have provided for you a fairly comprehensive bibliography of the articles that have appeared in the literature on energy conservation in commercial buildings. Using this bibliography, you will be able to assess for yourself the relevance of any energy saving technique for the buildings you work with.

Our problem usually is not knowing what's possible, but in knowing what's practical. Of the thousand and one ideas to save energy, which make sense for a particular building? How do we know? Are there any general guidelines? These questions seem to me to be at the heart of the problem of practicality and so let me give you my ideas about what's practical.

What's practical, of course, depends on how much energy can be saved for how many dollars spent to effect the savings. How do we know if its worthwhile to try to save any energy in a given building? We need something to compare the energy use with. If our building is much worse than a standard we probably should look for improvement. This is what we all do when we use our utility bills to decide to insulate, or our gasoline bills to get the car tuned up. Our standard is the bills we had before or our neighbors bills.

From data gathered by BOMA and reported by the FEA in 1977 the average annual energy consumption of office buildings in various regions of the U.S. was between 100 and 182 thousand BTU's per square foot for buildings existing in 1974. These buildings were of course all designed before the Arab oil embargo of 1973. BOMA gathers these statistics each year and even for current years they fall pretty much in the same range although there is a slight drop. You might say then, that using your neighbors bill as a comparison, you would be in good shape if your building used around 100,000 BTU's per square foot annually. Not so.

In 1978, HUD sponsored a study in which all the major trade associations participated where they examined the energy requirements of buildings designed after the oil embargo and built between 1975 and 1976. Each of the building designs was simulated to calculate the annual energy consumption. For these buildings, the average annual energy consumption in various regions of the country ranged from 50 to 76,000 BTU's per square foot. Nearly a 50% reduction across the board. In fact, in the climatic zone of south Texas, 20% of the surveyed buildings achieved an annual energy consumption as low as 40,000 BTU's per square foot.

I believe on this basis its not unreasonable to set as a comparison goal for energy consumption buildings in this area an energy budget of 50 to 100,000 BTU/ft^2 annually. This figure is closer to the 1975-76 survey result than to the average for all ages of existing buildings because the latter has a serious flaw for use as a goal. The "all-ages" building data has not considered separately the important difference between how a building is designed and how it is operated; while the 1975-76 data assumed good operation.

In the reference list there are several studies showing that nearly identical buildings can be operated in a manner so that one uses twice the energy of the other. I'm sure each of you is familiar with buildings that have undergone an energy conservation program and have reduced consumption by 50% or more with changes only in building operations. I know this topic is covered with examples in the next papers.

The problems of design and operation should be treated separately because they have separable impact on energy use and because they deserve different levels of attention in existing or in new buildings. Design considerations while they are paramount in developing a new energy efficient building haven't the same status in existing buildings. As a practical matter, there aren't very many design changes (structural changes - architectural changes) that are cost effective in existing buildings.

The references contain numerous examples of the types of design decisions which impact energy consumption and from all the studies I've read I think I have drawn two practical conclusions. First, for an energy conservative new building you can't be overly concerned about first costs. Not very many of the design choices that lead to lower energy consumption also lead to lower first costs. The only exception to this rule might be equipment sizing. In a well designed building it is not necessary to use as large a mechanical system as in a poorly designed building. Life-cycle costing is from an energy conservation point of view a more practical technique.

Second, there is no reason not to know the energy impact of nearly every design choice. As a practical matter its essential to simulate the various design alternatives and to understand their energy and cost-benefit impact. There are already ample computer programs available for energy simulation from the National Bureau of Standards, (NBSLD), Edison Electric Institute (ACCESS), E-Cube from the Southwest Research Institute in San Antonio, and many others. These programs will allow you to ask "What if I change this or that, what is the energy impact?" For existing buildings these programs can be used to assess the effect of a contemplated change say in insulation or glazing or some other change that seems within the budget.

Operational decisions are much more complex, easier to change, more difficult to maintain and can undo the best energy saving building design work. In this country we have not designed systems in buildings to minimize energy use. On the contrary, until recently we designed systems to take advantage of very low cost energy and to maximize occupant comfort (remember when the more electricity you used the cheaper it was). Its no surprise then to find that nearly all existing buildings waste energy - lots of it. And its no surprise that since most of the energy is used for heating, ventilating, and air conditioning that's where the biggest energy conservation target lies. The relative importance of heating or cooling changes with climatic region. Cooling energy required in the southwest usually is greater than heating. Space conditioning accounts for about 55-65% of the energy required in buildings, lighting uses about another 15-20%, equipment and power for fans, motors, and so forth use about 15-20%, and hot water heating uses the balance.

It's possible to look at a building at a moment in time and to ask "for that building with its systems and its internal and external environment, what is the most energy efficient strategy to provide for all current operations and comfort conditions?" It's my guess that in the overwhelming majority of cases the answer will be "turn something off", or "turn something nearly off. By "nearly off" I mean modulation appropriate for the conditions such as the temperature set point for chilled water or for "hot-deck" temperature. The same strategy applies to lighting, equipment and power and hot water.

The difficulty is of course that the particular strategy for one moment is not necessarily the same for the next moment and the systems designer who doesn't what to spend the time analyzing many moments can throw up his hands before a really good solution is arrived at. Again, the references that I distributed have listed many energy saving operational techniques and as always it is you who are the clever designers who will reap the benefits of the techniques others have used. The practical rule for operations seems to be "turn things off or nearly off" whenever you can get away with it. The complex nature of most building system and perhaps more importantly the complex nature of most building operators usually means that some type of building control automation system is called for to keep making the right decisions. This topic is covered in the next set of papers.

As a last practical suggestion, I advise you to simulate building operations as well as building design. It is more difficult to simulate building operations because the choices are greater simulation runs are therefore more costly and there are many more variables to keep track of, nevertheless; simulation can lead you through some complicated design choices to some surprising results as you'll see in at least one of the papers that follows.

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ENERGY MANAGEMENT SYSTEMS

FOR

SMALL COMMERCIAL/INDUSTRIAL APPLICATIONS

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A. INTRODUCTION

Widespread, extensive energy conservation on a consumer level will come only if economic incentives for both the consumer and utilities are compelling. For any economic incentives to be viable, however, opportunities for low cost implementation of an energy management program must be provided and consumers must be aware those opportunities exist.

There are two basic ways for a consumer to reduce his utility bill. The first is direct reduction in consumption with its associated energy conservation and reduction in utility costs. The second is modification of usage patterns to take advantage of the economic incentives provided by certain utility rate schedules (i.e., demand/energy or time-of-day).

In many situations, maximum (or even significant) benefits from available economic incentives require additional, effective energy management control devices. Typical control functions in an energy management system include demand control, scheduling, temperature control, lighting control and sequencing. Control devices may range from very elaborate and expensive minicomputer systems capable of controlling hundreds of points to a single point night setback thermostat. Each of these have their place and are effective when properly applied to appropriate situations. There has, however, been an important void in availability of sufficiently inexpensive control systems that fully utilize economic incentives available (in terms of payback and performance) for residential and small commercial/industrial applications. In most utilities, this range of service size accounts for large percentage, if not the majority, of the nondeferrable peak usage and consumption requirements. In following sections, the requirements of such control systems and problems associated with their application will be discussed as well as methods and equipment that may be employed to make them viable energy management tools for both consumers and utilities.

B. CONTROL SYSTEM REQUIREMENTS AND CONSTRAINTS

Energy conservation programs face a difficult dilemma when both facilities and equipment were designed when energy was inexpensive. To solve the problem, sources of energy loss must be identified and eliminated, and optimal (from consumption, comfort, and convenience standpoint) operating points or limits defined. Then a control system with sufficient capabilities to meet the operational requirements, while taking advantage of any usage-pattern related economic incentive, can be configured to minimize total energy costs. Even very small applications can require a complex and sophisticated control strategy which is most cost effectively implemented with a microcomputer control system.

Independent, discrete control devices often prove inadequate when an attempt is made to apply a comprehensive control approach to an entire system. For example, in certain situations night setback thermostats may be very effective for consumption limiting by allowing the user to control to limits of the overriding temperature constraint. In a system where demand is a consideration, however, demand peaks may result. Even sequencing produces the undesirable result of reducing potential energy savings. By combining demand and temperature controls, peaks can be limited while the initiation of the recovery period is delayed as long as possible to achieve maximum consumption savings.

A great deal of diversity in control requirements exist in applications of energy management systems. For this reason, flexibility in a control system is very important. Each application has different input information that must be supplied and has specific load types that must be controlled. For example, baseboard electric units are widely used in residences and small business with compressor loads being more common in restaurants and supermarkets while large scale lighting management may be important in a department store. Each of these have significant demand and consumption requirements, but the control approach actually employed will vary a great deal for the different applications. Different criteria in selecting a control strategy may be important in various situations. For example, a retail store manager must determine the relative importance of a customer's comfort and the demand limit.

Another situation that calls for adaptability in the controller is the nonuniformity in utility rate schedules. The system designer must determine whether demand rate schedules are available and, if so, the relative importance of demand and energy components. When time-of-day rate incentives are available, they may be on an energy basis, a demand basis, or combined. These and many other application variations make a certain amount of field or application level configuration flexibility desirable thereby allowing standardized production runs of total system controllers where custom manufactured or discrete devices might otherwise have been required.

Since energy management system users in residential or small commercial/industrial applications may be unfamiliar with energy management concepts and technology, certain user-oriented features should be included in the controllers designed for such applications. Because some consumer-level interaction is normally required, routine communications must be simple and straight forward. Monitoring, emergency overrides, establishment of set points and time-of-day scheduling are typical of information that the consumer would communicate to and from the system. In addition, provision for power-down and failure mode operation should be made to insure against energy cost increases under these conditions. It is also important for the user to have a feeling of control over his energy costs and to have recourse if discomfort or inconvenience is resulting from the control action.

Finally, the system must yield significant savings. As was mentioned before, costs associated with the control system must be low enough or there will be no significant move to take advantage of available economic incentives. Depending on the user and the actual application, either first costs (and/or the availability of appropriate financing programs) or an evaluation based on return on investment or payback period may be the more important criteria. Typically, a payback of 18 months to 3 years is considered necessary by purchasers of energy management systems.

C. THE CONTROLLER AND THE UTILITY

Although provisions in the recent National Energy Act require utilities to evaluate the applicability of different rate schedules that would encourage conservation of energy and efficient use of facilities and resources, effective and inexpensive energy management control devices must be available to make any potential economic incentives viable as an energy conservation tool for both the consumer and the utility.

It is important to note that it is often not in an utility's best interest to conserve energy beyond maximization of plant efficiency. Further, given pricing systems that pass along fuel costs to consumers, even expenditures for improvements of plant efficiency may not be economically justified. Depending on the particular utility's situation, it may actually be more strongly motivated to maintain or increase total consumption levels. On the other hand, most utilities can benefit from shifting consumption from peak periods to create a more level demand, with the resulting improvement in load factor (the ratio of average to peak power). Increasing the load factor may bring several benefits to the utility including:

1) Deferring or eliminating requirements for new power generation facilities or the need to purchase peak power (with its high demand component charge) from other utilities.

2) It can reduce high peaking fuel costs (which may or may not be passed along to consumers).

3) Efficiency gains and energy savings may be obtained by operating base and intermediate generating plants closer to capacity.

Whatever a given utility's motivation, the consumer's motivation will come from cost reductions associated with limiting demand when a strong demand component charge is applied to billings. The consumer's effort to reduce demand may or may not have the secondary effect of reducing total energy consumption.

Two considerations are important for demand limiting at the consumer level. The control applied must involve little or no discomfort or inconvenience and, for maximum effectiveness, the consumer should be able to select, under normal circumstances, the extent to which demand limiting control is applied. In this way the consumer will feel in control of the situation (rather than feeling at the mercy of the utility), and the rather subjective judgment of comfort level is in the consumer's hands. Since the user will realize that any increase in a demand limit setting will result in a corresponding increase in his utility bill, maximum system effectiveness can be maintained.

Two approaches are typical of those employed by utilities to limit their demand for residential and small commercial/industrial applications. A utility may generate a signal that is used to turn off preselected consumer loads (i.e., hot water heaters) during peak periods thereby shifting the usage until other utility consumption drops enough so the energy required can be supplied without a peaking problem. Drawbacks of this approach include the possibility of only shifting the peaks rather than actually leveling them and the rather restricted potential of the approach. With more complete control, demand may be reduced by more than twice as much without undue discomfort or inconvenience to the consumer. The second approach leaves the demand control in the hands of the consumer with the assumption being that direct economic benefits will encourage consumers to install and apply as much control as possible to their situation. Utilities may take roles ranging from very limited participation to active promotion in this type of program. Problems with this approach include lack of sufficient consumer awareness, controller financing, and insufficient penetration of potential applications to significantly benefit the utility.

A preferred approach in many situations is a combination of the two above approaches where the consumer normally establishes his demand limit but where the utility may override to an alternate demand limit setting (and perhaps a different strategy) when a peaking crisis is faced. Take, for example, a small office building in Colorado with all electric service which may have an average monthly demand at 65KW when no controls are applied. The facility manager is likely to find he can have adequate comfort levels with an average demand limit setting on a control device of 30KW providing nearly $125 per month savings on his utility bill. His economic incentive is therefore significant. When the utility faces a peaking situation it can provide an external actuation signal that would cause a branch in the controller program establishing a temporary demand limit of 24KW and selecting a different control strategy to be employed. This method allows the utility to have a better defined sheddable load so it can more effectively and economically manage periods of high consumption and, if employed on sufficiently large portion of the load, can significantly lower overall KW demand requirements and improve operational efficiency.

When a control approach meeting a given utility's requirements is defined it can make good economic sense for the utility to actively support purchase and installation of necessary control equipment on a utility wide basis. Economic evaluation of plans to finance consumer purchase or lease programs along with the savings resulting from improved load factors will, in most cases, indicate a very attractive investment opportunity. Without utility participation and the availability of the cost effective control device no significant reduction in peak demand or the benefits gained by limiting the peak will be realized.

D. SENTROL™ ENERGY MANAGEMENT SYSTEMS

Two lines of computerized management systems are offered by Horizon Solar Corporation. The Sentrol™ Series 600 is designed for residential and smaller commercial applications such as restaurants, convenient stores and small offices while the Sentrol™ Series 4000 is oriented towards small to medium sized commercial/industrial installations such as supermarkets, motels, department stores and small manufacturing operations. By selection of the appropriate control system, basic energy management control functions can now be efficiently and economically implemented on total system basis. Such inexpensive control systems, in conjunction with economic incentives provided by utility rate schedules, provide the key to obtaining maximum energy conservation and minimum energy costs for smaller applications.

The Sentrol™ Series 600 includes several different models which feature such functions as demand limiting, time-of-day temperature control, scheduling/duty cycling, and combinations of these. In additions, it can be quickly configurated for specialized applications. It is generally characterized by a well defined control algorithm with specific application types in mind. Typical field programmable parameters include demand limits, meter ranges, minimum on/off times, load interlocks, prioritization strategies, dead bands and anticipation for temperature control functions, as well as capability for set point and strategy branching based upon recognition of a utility generated interrupt signal. Other key features include simple "prompting" program input, alarms, a self-calibration capability for long term stability and minimum service, and attractive packaging.

The most imporant single feature of the Series 4000 Energy Management Controller is a three-level programming approach that makes the Series 4000 straightforward to apply and easy to use in a wide variety of applications. It is designed for maximum flexibility with extensive field programmability. Factory-level programming provides a basic operating system, data aquisition formats, and fundamental energy management capabilities. The second level programming is that provided by the specifying engineer contractor or designer and is termed system definition programming. At this level, each load is defined and controlled on an individual basis and attribute assignments are determined. This information is stored in permanent but alterable memory (electrically-alterable read only memories or bubble memory depending on the size of the system). Basic parameters programmed at the system definition level include: demand priority groups, demand limits, special day groups, sensor control variables sequential group specifications, power monitor variables, load interlocks, and load constraints.

The third level of programming is provided by the user and is accomplished by a straight forward "prompting" keyboard and alphanumeric display. Parameters for routine user adjustment include: demand limit (override of system definition values), sensor set points, time-of-day scheduling, clock, calendar, and individual load overrides.

In addition to the control units described above, the Sentrol^{tm} total system approach features modular input/output and relay panels which allow the consumer to purchase only those capabilities which are required for specific applications while allowing maximum flexibility in system design and future expansion. The input/output panels contain functional modules for power monitoring, temperature, digital input/switch monitoring, alarm monitoring, or analog signal input to provide the controller the information about system status it requires to make decisions. The relay panels contain normally open/normally closed signal or power relays needed to implement the controller decisions. The relays are available in several power ratings and types for different applications. The application of Sentrol^tm Energy Management Systems can result in significant savings in design and installation labor as well as significant reduction in total energy costs.

E. SUMMARY

The potential for energy conservation will be realized only when economic considerations make it clear to utilities and consumers alike that it is in their best interest to participate in comprehensive energy management programs. Full realization of the potential for energy savings and reduction in energy costs will normally require the utilization of additional, sophisticated control devices. When energy management systems are properly configured, both the utility and the consumer can benefit substantially, but active participant roles by utilities are likely to be necessary to achieve sufficient consumer acceptance and utilization to significantly impact a utility's load factor. Recently, low cost, computerized control devices have become available which can help provide cost effective implementations of energy management programs.

TEXAS INSTRUMENTS' ROLE IN ENERGY MANAGEMENT

By Ed Van Riper

A. TEXAS INSTRUMENTS

Texas Instruments, Incorporated is a world-wide manufacturer of electronics for industrial and consumer usage built on a technological base in the semiconductor industry. We are a fast growing company, with sales exceeding $2.5 billion in 1978. We are committed to advancing technologically in the base semiconductor business, consumer products, and distributive processing.

B. THE 5TI

The 5TI programmable controller was introduced in 1974 as a part of our overall distributive processing strategy. It was designed to provide industry with low cost answers to then costly programmable controllers. Programmable controllers are rapidly replacing relay, timer, counter, and shift register logic in industrial controls. T.I.'s contribution with the 5TI was a lower costing and easier to program system.

The 5TI has been a tremendous success. It has provided the industry with a practical solution to their previous control nightmares, and there are well over 15 thousand systems in the field, spanning every conceivable type of application. As a result, T.I. is number one in systems sold.

As the energy crisis increased, the need for equipment to reduce energy usage became apparent. Many alternatives were considered. Some people embraced large expensive computer systems, and others steered their way towards small dedicated controls. T.I., at this time, was not involved, and did not participate in the energy management industry until approached by many users, contractors, and consultants.

It was obvious that the 5TI system could provide a middle ground. That is, it was a low cost, reliable, and flexible system that would do 95% of the job at a very low cost compared to other available systems.

Since T.I. is basically a components manufacturer, we did not set up a division that would participate in the energy management business at a systems level. Rather, our course was to provide components and assistance to those people who could make good use of them. After all, our interest is in providing good equipment at an ever improving value. To that end, the increased volume of component sales to energy management users would help bring the overall system down the price/learning curve and be of benefit to all of our customers.

Our strategy, therefore, was to sell the 5TI system for energy management in two ways:

1. Technical End Users

We already had a full-time field sales force to sell the 5TI industrially. For the sophisticated user, we could safely sell him the components, and he would know how to apply them to the final application. Normally, an end user will have an engineering staff and other support.

2. Non Technical End Users

For smaller facilities without resources to afford engineers and people capable of applying the 5TI, we planned to work through energy management consultants, contractors, and original equipment manufacturers. These people could take the best aspects of our system and apply them to the user's needs using the versatility of the programming and their expertise.

This, then, was our plan for handling the ever increasing interest of the energy management industry in the 5TI.

The 5TI system is capable of providing a user with load cycling, real time clock, power demand, and other custom logic features. The programming of the system is accomplished through the use of standard industrial ladder diagrams that are known to most electricians and maintenance people. Because of the ease of programming, it can be easily adapted to custom jobs that might involve more than just heating and air conditioning loads. In addition, the equipment is built for operation in a harsh industrial environment, and the interfaces between the low level logic of the central processor and the real world are easily understood and serviced.

An example of programming a simple scheduling of a water heater for a five day work schedule between eight A.M. and five P.M. has been attached. The logic for determining when the contacts activate and deactivate the load are all obtained from a real time clock, which is programmed according to the diagram on pages 4, 5, and 6, attached. This is very typical of one of the loads that might be found to be programmed into the 5TI.

Also attached is an application note showing how the 5TI might be integrated with a power demand meter for power demand control. All sorts of variations of programs can be applied to a power demand control method, since the logic timing and counting functions all are easily varied to suit one's best concept of power demand.

In addition to the system itself, the 5TI also has peripherals that will allow it to communicate with computers, terminals, and other standard communications devices. It also has a timer-counter access module, which would allow an operator to change timing and counting functions without changing other parts of the program.

C. <u>THE PM550</u>

Since the introduction of the 5TI system, T.I. has also introduced the Program Master 550. Where the 5TI is basically a relay logic replacement system operating only on switch closures, the PM550 is far more sophisticated. It has the capabilities of 3-mode feedback loop control, math features, the same logic features as the 5TI, and complete data handling capabilities. It can interface with most standard analog devices, thereby providing the user with a system that provides enthalpy control and other similar processes.

The PM550 is a dual-based microprocessor system which is easily programmed using a prompting programmer. The prompting programmer actually coaches you along as you are doing your programming and will not let you make mistakes. Many customers are now thinking of using the PM550 instead of the 5TI system because of its greater sophistication in spite of the fact that its price is around four to five times higher than that of the 5TI.

If there are questions concerning either the 5TI or the PM550 systems, please do not hesitate to contact:

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3.0 5TI ENERGY MANAGEMENT REAL TIME CLOCK PROGRAM DESCRIPTION

GENERAL

The time base for the clock is provided by a 0.1 second timer. The timer is programmed with a preset of 600 and results in an output every minute at CR0. The signal at CR0 is divided by sixty with a counter and gives a signal output at CR1 every hour. The hours are counted in increments of 24 and at CR2 an output is present once a day. CR4 gives a weekly output. CR3 is used to count the work days. Thus the week can be divided into any number of days on and days off. If Saturday operation is required, the work day counter is merely programmed for six. In the day counters, the days of the week are designated as: Monday is 0, Tuesday is 1 Wednesday is 2, etc.. Sunday is 6 and can be observed in locations 26 and 33.

Similarly, the hour counter accumulates 24 hours; NOON is 12, 1:00 P. M. is 13 and 11:00 P. M. is 23. The current hour is stored in location 19. Hence, Thursday at 2:36 P. M. would be read out of the Real Time Clock as:

LOCATION	DATA	COMMENTS
26 and 33	3	Designates Thursday
19	14	Designates 2:00 P. M.
12	36	Designates 36 Min.

AUTOMATIC SYNCHRONIZING

The system can be synchronized by providing a reset pulse to X0 at Midnight on Sunday. The signal resets the timer and counters to zero and serves as the starting point for the Real Time Clock.

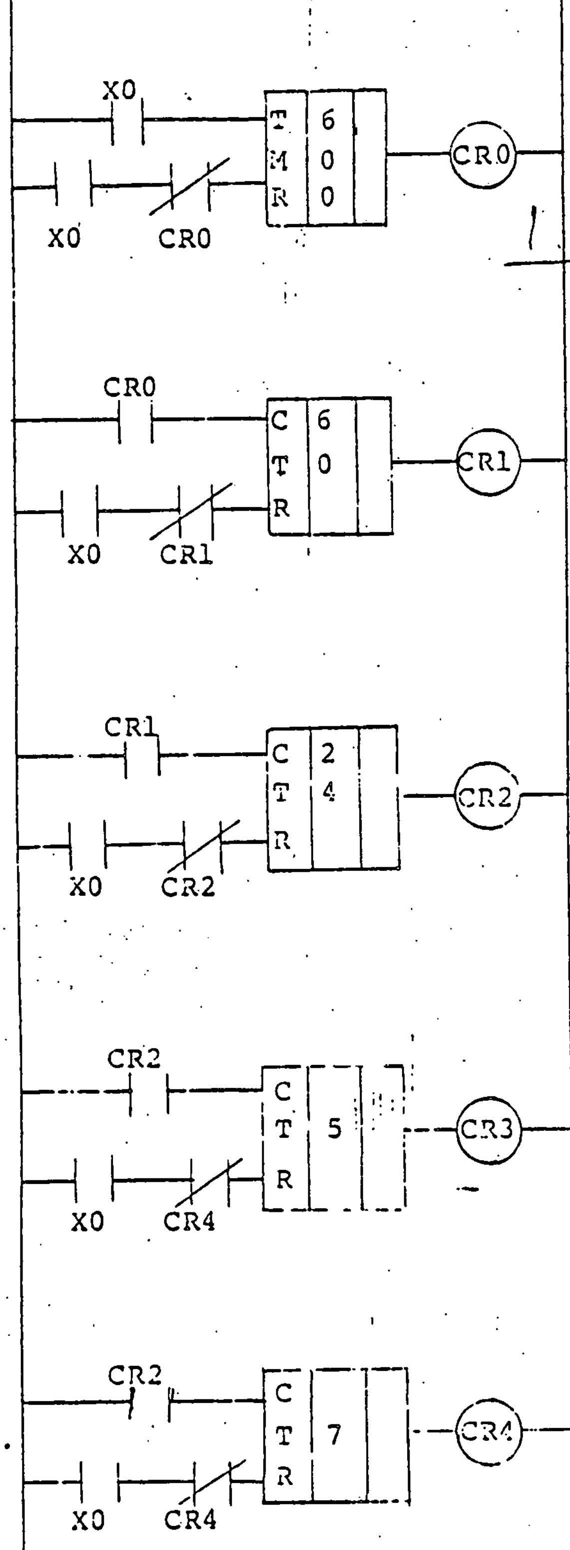
PRESETTING

Whether in R/W or PROM, current word locations of timers and counters can be written into with the R/W Programmer. This feature makes presetting of the Real Time Clock a trivial task. One could even synchronize to a wall clock by resetting the counters with X0 when the second hand of the wall clock passes 12. The remainder of the procedure would be to write into the current word locations of the day, hour and minute counters. Hence, if you wanted to preset the Real Time Clock on Saturday at 9:30 A.M. you would enter the following data:

Location	Data
26 and 33	5 (Saturday)
19	9 (9:00 A.M.)
12	30 (30 Minutes)

FUNCTION	LOC.	TYPE	I/O	#	COMMENTS
	0	STR	X	0	
	1	STR	X	0	
	2	AND NOT	CR	0	
MIN. TMR.	3	TMR	-	-	
	4	-	-	600	
	5	-	-	-	
	6	OUT	CR	0	OUTPUT EACH MIN.
	7	STR	CR	0	
	8	STR	X	0	
	9	AND NOT	CR	1	
	10	CTR	-	-	
	11	-	-	60	
	12	-	-	-	CURRENT MINUTE
MIN. CTR.	13	OUT	CR	1	OUTPUT EACH HR.
	14	STR	CR	1	
	15	STR	X	0	
	16	AND NOT	CR	2	
	17	CTR	-	-	
	18	-	-	24	
	19	-	-	-	CURRENT HOUR
	20	OUT	CR	2	OUTPUT EACH DAY
	21	STR	CR	2	
	22	STR	X	0	
	23	AND NOT	CR	4	
HR. CTR.	24	CTR	-	-	
	25	-	-	5	
	26	-	-	-	CURRENT DAY, MON. = 0
	27	OUT	CR	3	OUTPUT EACH 5 DAY INTERVAL
	28	STR	CR	2	
	29	STR	X	0	
	30	AND NOT	CR	4	
	31	CTR	-	-	
WORK DAY COUNTER	32	-	-	7	
	33	-	-	-	
	34	OUT	CR	4	OUTPUT EACH WK

LADDER



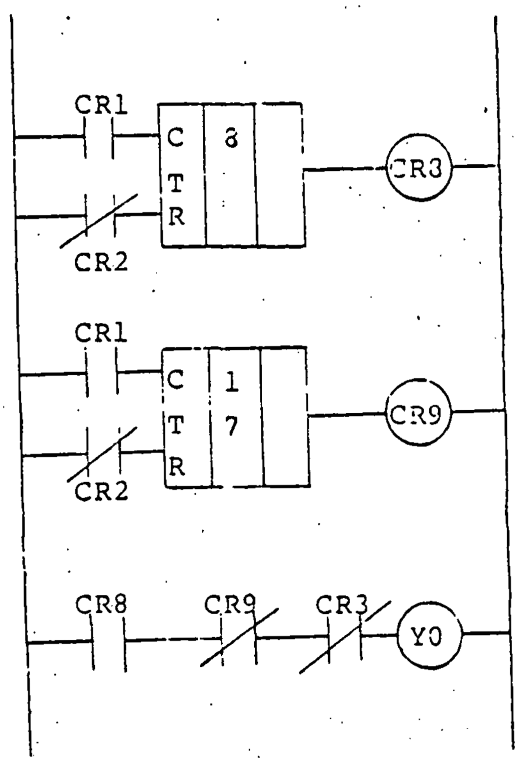
7-DAY CTR.

MON. = 0
TUES.= 1
etc.

EXAMPLE

The use of the Real Time Clock to control loads in accordance with the time-of-day is accomplished with additional counters. Consider a load, Y0, which is to be on from 8:00 A.M. to 5:00 P. M. Monday through Friday. A ladder diagram and program to accomplish this is given below.

LADDER



PROGRAM			COMMENTS
STR		CR 1	HOUR INPUT
STR	NOT	CR 2	DAILY RESET
CTR	-	-	
-	-	8	
-	-	-	
OUT		CR 8	TURNS ON AT 8:00 A.M.
STR		CR 1	
STR	NOT	CR 2	
CTR	-	-	
-	-	17	
-	-	-	
OUT		CR 9	TURNS ON AT 5:00 P.M.
STR		CR 8	ON AT 8:00 A.M.
AND	NOT	CR 9	OFF AT 5:00 P.M.
AND	NOT	CR 3	MON. THRU FRI.
OUT		Y0	OUTPUT TO LOAD

If control were desired to a fraction of an hour (minutes) additional counters would be needed to count the minutes. Presetting of the load control is accomplished by insuring that the current words of the counters associated with the load are identical to the current-words of the hour counter (Loc. 19), and day counter (Loc. 33).

5TI PROGRAMMABLE CONTROL SYSTEM

applications

POWER DEMAND CONTROL

Since its introduction in 1969 the programmable controller has efficiently replaced relay and card logic control systems. The 5TI with its hardware modularity and programming simplicity is a third generation machine particularly suited for power demand control.
The cost of energy will continue to rise and industrial and commercial users pay a premium for the privilege of using electric power at a particular time of day, rather than using the same amount of energy at some other time. This application note describes a power demand control system which will lead to significant savings for consumers whose demand for electric power fluctuates.

The demand rate is continuously monitored by the utility demand meter over discrete intervals (usually 15 or 30 min.), integrating kilowatt hour usage throughout the demand interval. When the demand interval has been completed, the slate is wiped clean and the meter begins to look at the next interval. The consumer is charged according to the highest peak recorded in any interval during the billing period.

Figure 1

The block diagram of figure 1 depicts a system which will shed (turn off) deferrable loads when the power consumption rate exceeds a predetermined upper limit and restore these loads when the consumption rate is below a lower limit. Deferrable loads are those which may be interrupted without disrupting production or endangering workers and typically have long thermal time constants as furnaces, compressors, hot water heaters and air conditioning outlets.

The consumption rate limits at which loads are shed and restored are programmed into the 5TI and easily modified for on-line optimization. The demand meter provides a variable pulse stream to the 5TI which is dependent on the consumption rate. The greater the consumption rate, the greater the number of pulses in a fixed sample time interval. If the number of pulses received by the 5TI exceeds the programmed value, the loads are sequentially shed at a rate of one load per sample interval. Loads are shed until the number of pulses received in the sample interval is less than the programmed value. If the number of pulses is less than the programmed lower limit, the loads are restored on the basis of "first off first on". The dead zone, the difference between the high and low limits, eliminates the constant switching of loads.

The inputs to the 5TI from the demand meter and manual controls, and the outputs which control the loads are accomplished with the standard input/output subsystem of the 5TI. Expansion to control additional loads can be achieved by adding discrete output modules and modifying the program.

Example

A well known manufacturing organization has installed a 5TI Power Demand Control System and realized the cost savings shown below. The savings is based on lowering the peak demand 1000 Kw from a typical monthly peak of 12,120 Kw. This is accomplished by controlling the cycling of thirteen batch furnaces and two air conditioning units. The air conditioning units are not simply turned on or off as the furnaces but controlled by shifting vanes in the compressor and thus controlling the compression ratio.

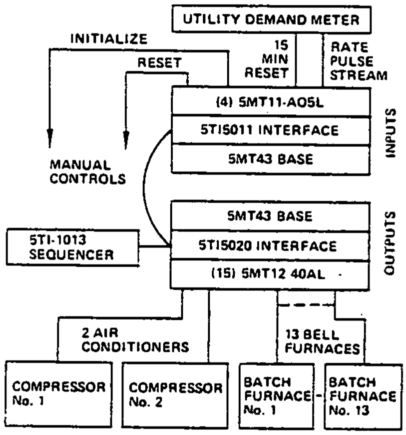
The major portion of the savings is realized by the energy charge which is calculated in the following manner. The total energy consumed, 6,192,000 Kwh, is broken down by multiplying the demand, 11,120 Kw by 200 hours to obtain 2,224,000 Kwh as the first segment. The first 50,000 Kwh of the first segment has a charge rate of $.02317. The second 50,000 Kwh of the first segment has a rate of $.02017 and the remaining balance of the first segment 2,124,000, has a rate of $.01707. Hence the first 2,224,000 Kwh has a total charge of $38,423.68. The next three 100 hour segments, 1,112,000 Kwh, have the following charge rates $.01597, $.01137 and $.01037. The first four segments amount to 5,460,000 Kwh. The remaining balance of 632,000 Kwh is charged at a rate of $.00987 making the total energy charge $86,595.04.

HARDWARE DESCRIPTION

The hardware configuration and cost of the system is shown in figure 2. There are 2 inputs to the 5TI from the demand meter, a 15 minute reset signal and the consumption rate signal. Both signals are contact closures and have a minimum pulse width of 29 milliseconds. The consumption rate signal has a maximum repetition rate of 17 Hz per second. The inputs are accepted by 5MT11-AO5L input modules. All outputs are 5MT12-40AL modules which control the loads. The system can be easily expanded to control 24 loads by adding discrete output modules in the vacant module positions of the I/O racks. Further expansion is possible by adding I/O racks, modules and memory as required.

Installation costs vary considerably depending on the size of the loads, distances for the cabling and type of electrical system. In the installation cited, each load control unit averaged out to approximately $100.00 per load and included an auxiliary contactor and switch. The cabling which was No. 14 wire in EMT averaged out t $2.50 per foot, installed within the build ing. It should be noted that installation costs will increase greatly if loads at ·mote locations are controlled. Tele- ıone lines can be leased or radio equip- ...ent installed to provide remote load control. In this installation the utility company charged $270.00 for the demand meter retrofit.

Two manual controls of the system, the Reset and Initialize signals, allow restoring of all loads and initializing of the system, respectively.



SYSTEM COST

1 - 5TI-1013 SEQUENCER	$ 670
2 - 5MT43 BASES @ $60	120
1 - 5TI5011 INTERFACE	70
1 - 5TI5020 INTERFACE	70
4 - 5MT11-AO5L INPUT @ $10	40
15 5MT12-40AL OUTPUT @ $12	180
2 - 5TI5-25808 CABLE @ $17	34
TOTAL	$ 1184
INSTALLATION COSTS (EXPENSES)	$ 3200
TOTAL	$4384
PERIPHERAL EQUIPMENT	
1 - 5TI-2000 PROGRAMMER	$ 530
1 - 5TI-4000 SIMULATOR	220
TOTAL	$ 5134

Figure 2

PROGRAM DESCRIPTION

The program for the system consists of 237 words and with each load that is added twelve additional program words is required. A flow diagram of the program is given in figure 3. A sample time interval of 30 seconds is established with words 0 through 6 of the program. A shed counter and restore counter accumulate demand pulses. If the number of pulses exceeds 7 or more a load is shed and the timer, and counters are reset. If the number of pulses accumulated by the restore counter in the sample time is less than 5 a load will be restored providing one was previously shed. If more than one load has been shed, then the load that was shed first (off the longest) is restored first. The timer and counters are reset by the shed counter or the expiration of the 30 second sample time interval. If the shed counter accumulates more than 7 pulses at any time, a load is shed and the timer and counters are reset to zero. Likewise, if the timer times out everything is reset and a new 30 second sample time is started.

The sequential shedding of the loads is controlled by a master ring counter which is advanced on each signal from the shed counter. X3 is a manual control which serves to reset or shut off all stages of the ring counter and restore all loads. X4 is a manual input which allows the initialization of the master ring counter by energizing one of its outputs, thus enabling the shedding of a load.

All loads are restored at the end of the 15 minute time interval (X2) and the timers and counters reset to zero. The information in the master ring counter contains the information of which load will be shed at any time. The slave ring counter is updated at the beginning of the 15 minute interval with the information contained in the master ring counter and serves to provide the information of which load is restored.

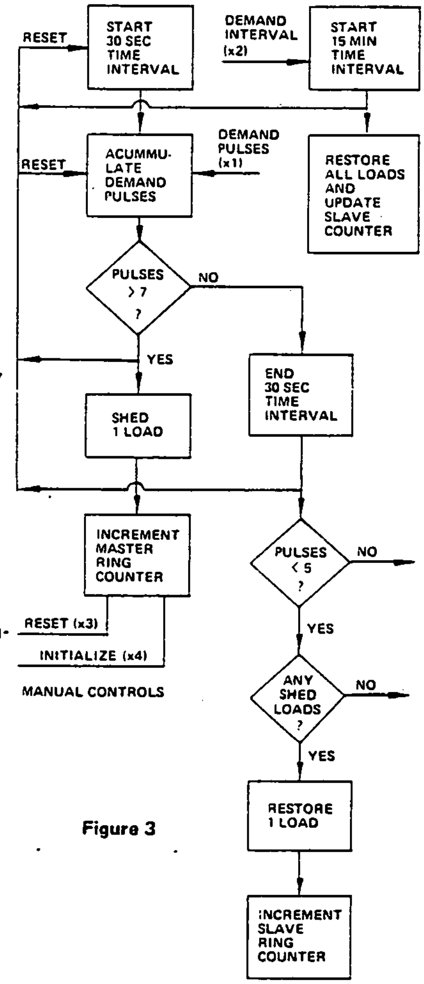


Figure 3

UTILITY TARIFF*

Without PDC

DEMAND: 12,120 KW	
1st 500 KW	$ 700.00
Bal. 11,620 @ $1.30/KW	15,106.00
Total	**$15,806.00**
ENERGY: 6,192,000 KWH	
(200 KWH) (12,120)	2,424,000 KWH
1st 50,000 @ .02317	$ 1,158.50
2nd 50,000 @ .02017	1,008.50
Bal. 2,324,000 @ .01707	39,670.68
Next 1,212,000 @ .01597	19,355.64
Next 1,212,000 @ .01137	13,780.44
Next 1,212,000 — .01037	12,568.44
Bal. 132,000 @ .00987	1,302.84
Total	**$88,845.04**
FUEL CHARGE:	
6,192,000 @ .01819....	$112,632.48
METER DISCOUNT:	
$217,283.52 x $.025	($5,432.09)
DELIVERY DISCOUNT:	
··,120 KW x $.12	($1,454.40)
·ITAL ELECTRIC BILL:	**$210,397.03**
Average cost	$.03398 / KWH

With PDC

DEMAND: 11,120 KW	
1st 500 KW	$ 700.00
Bal. 10,620 @ $1.30/KW	13,806.00
Total	**$14,506.00**
ENERGY: 6,192,000 KWH	
(200 KWH) (11,120)	2,224,000 KWH
1st 50,000 @ .02317	$ 1,158.50
2nd 50,000 @ .02017	1,008.50
Bal. 2,124,000 @ .01707	36,256.68
Next 1,112,000 @ .01597	17,758.64
Next 1,112,000 @ .01137	12,643.44
Next 1,112,000 @ .01037	11,531.44
Bal. 632,000 @ .00987	6,237.84
Total	**$86,595.04**
FUEL CHARGE:	
6,192,000 @ .01819....	$112,632.48
METER DISCOUNT:	
$213,733.52 x $.025	($5,343.34)
DELIVERY DISCOUNT:	
11,120 KW x 0.12	($1,334.40)
TOTAL ELECTRIC BILL:	**$207,055.78**
Average cost	$.03344 / KWH

SAVINGS: $3,341.25 MONTHLY

*August 1975

For further information write or call:

TEXAS INSTRUMENTS INCORPORATED
INDUSTRIAL CONTROLS MARKETING
ATTLEBORO, MASSACHUSETTS 02703
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INCORPORATED

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ENERGY CONSERVING OPPORTUNITIES USING TEMPERATURE CONTROLS

Mr. John Terhune, Marketing Sales Manager

Comfort Controls Marketing, Commercial Division Honeywell where?

Millions of dollars are being spent on research to find new energy sources, new thermal storage techniques, and new control schemes. But it can take years to develop research results into commercial applications. In the meantime there is a solution. Temperature controls.

You have all heard a great deal about temperature control devices and temperature control sequences which not only save energy but provide very good payback. Many of these devices and sequences have been available for years, but our present concern with energy conservation has given them new emphasis and added credability. Even with this added emphasis, however, it is amazing how many specifications are written that ignore many basic conservation opportunities.

Temperature controls are available today and can be designed into new buildings at little or no added cost....

A well conceived temperature control system is an absolute must if more sophisticated computer based energy monitoring and control systems are ever to realize their true potential. Millions of dollars are spent on designing complex costly software to operate HVAC equipment. No amount of computer sophistication can make leaky valves and dampers or misapplied room controls energy efficient.

I want to take a few minutes this morning to reexamine some of the control basics which contribute to an energy efficient system.

For the purposes of discussion I've divided an air handler into three sections:

1. *Air mixing section*
2. *Tempering or coil section*
3. *Room thermostats*

The air mixing section consists of the outdoor air damper, return air damper and exhaust air damper. Here are some of the things that can be done to make this section more energy efficient.

Use dampers which are rated at 1/2% leakage. Typically if low leakage dampers are not specified, the dampers delivered on equipment or to the job site leak between 10% to 30% of full flow when in the closed position. The leakage alone is adequate to handle most minimum outdoor air requirements. In a 80,000 sq. ft. office building with a 60,000 CFM system, the leakage would bring in 18,000 CFM of unwanted outdoor air. In Chicago this would cost an owner approximately $1 per hour during the heating season when the fans are on and dampers are supposed to be closed. This may not sound like much but if this occurs 6 hours per day, 5 days a week for the heating season, it costs that building owner better than $900 a heating season.

Control min. fresh air requirements. Typically dampers are set at a fixed min. substantially greater than required by codes. In fact if you have one of those dampers I've just mentioned, you're at minimum before you start to open the dampers. It is not uncommon to see dampers set to 20% open for 20% air flow. Looking at a damper flow curve you will see that you get substantially more than 20% air at minimum. Obviously, adjusting the minimum damper position will correct this in many cases. On VAV systems however, as the inlet vanes throttle open, you will draw in more OA than is required. Controlling this minimum via a flow controller and a separate minimum fresh air damper can substantially reduce the quantity of OA requiring mechanical cooling or heating

After selecting low leakage dampers and assuring ourselves that only minimum outdoor air is being introduced through positive control of OA flow, we need a suitable method to control the proportions of OA and RA during the cooling season. Historically this has been through the use *of a dry bulb economizer. The economizer prevents the introduction of hot outdoor air during the cooling mode but allows its introduction when suitable for free cooling.*

In this geographic area dry bulb economizers are sufficient. In other areas enthalpy controllers provide additional savings. An enthalpy control system compares the total energy or enthalpy of the OA to the RA and uses the air source with lowest total energy.

The second portion of the air handler is the coil section. Here I want to touch on only one concept-that of space temperature feedback.

Traditionally on dual duct or multizone units the hot deck temperature was reset as a function of outdoor air. As the outdoor air temperature increased, the hot deck temperature was decreased. The cold deck was maintained at a fixed discharge air temperature.

A more efficient way of controlling the decks is to sense the demand for heating or cooling in each zone or selected representative zones and then reset the hot and cold decks based on the zone of greatest demand. This more accurately represents the demands of the building and allows the output of the machine to more closely match requirements of the space. This concept can be applied to constant volume reheat or recool systems.

To apply space feedback simply requires feeding a control signal back from representative zones and using this signal to reset duct temperatures either upward or downward as space requirements dictate. Space temperature feedback plus economizer control can reduce the heating/cooling energy costs of a multizone by as much as 50% when compared to units without these features.

Finally, the heart of the system, the room thermostat. Most people consider that room thermostats are all pretty much the same. This isn't true!

In the Commercial Division of Honeywell alone, we have over 60 different pneumatic room thermostats, each designed for a different application. Of these 60, there are two I specifically want to discuss; the Limited Control Range Thermostat and the Zero Energy Band Thermostat.

Two occupant actions can instantly defeat a good conservation program - the first, indiscriminate resetting of thermostat set point, and the second, adjusting thermostats so the heating and cooling overlap, providing simultaneous heating and cooling to the same space.

The Limited Control Range Thermostats were specifically designed to prevent occupants from adjusting space thermostats to settings beyond some predetermined point. The ability to set limits on thermostat set points has been available for years by fixing set point stops in the device. Unfortunately occupants are highly ingenious folks. They have devised ways of defeating most schemes to restrict set points whether they're set stop screws, locked thermostat covers or factory fixed stops. If the occupant cannot find any other method, he rips them off the wall. Replacement sales for these devices are good business. The Limited Control Range device is one used on a heating only or cooling only system. This includes systems with central changeover from heating to cooling. It provides complete freedom of set point adjustment. Regardless of how high the thermostat is set while in the heating mode, it will only control up to some maximum limit - in this particular case 72%. Likewise, in cooling, it can be set anywhere but will never control at less than 78%. It removes the frustration of physically restricting set point adjustments while at the same time conserving energy by restricting the actual control point.

A second family of thermostats are what Honeywell calls the Zero Energy Band Thermostats. The concept of two set points - one for heating and a different one for cooling is gradually gaining occupant acceptance. In *systems with central changeover, this can be accomplished with a summer-winter thermostat which changes both the switch action and set points automatically. In systems which supply both heating and cooling on thermostat demand, the engineers have been forced to go to two separate devices with different set points. But anytime you have two thermostats controlling one space you're asking for trouble.*

The Zero Energy Band Thermostat is designed to avoid this trouble. The ZEB device has a separate heating set point and cooling set point so that each is adjustable. They are physically impossible to set to overlap heating and cooling. The heating can be set at 68° and the cooling set at 78°. In this case, heating can operate between 68 and 70, and cooling between 76 and 78. Between 70 and 76 only the fan operates, no mechanical heating or cooling is supplied to the space.

These thermostats can be used on any system with both heating and cooling available such as VAV with reheat, four pipe from coil units, single zones with both heating and cooling and multizones.

Much of what I have talked about is review. However it is basic in the sound design of control systems and bears repeating. If used, it will provide substantial energy and dollar savings. With this, let me turn the session over to Erling Hallanger who will discuss utilization of EMCS systems.

EFFECTIVE UTILIZATION OF ENERGY MANAGEMENT SYSTEMS

Erling C. Hallanger, P.E.

February 15, 1979

A. INTRODUCTION

Energy Management Systems can and do save energy. The purpose of this talk is to explore the various factors that can insure that the system you select or purchase will do its job properly. To put it another way, "Will your Energy Management System really work and really save energy?" This subject is important because there are still 12 billion square feet of non-residential buildings and less than five percent have a complete, effective energy program in place.

B. FIRST CRITERION - ECONOMICS

Before selection of an Energy Management System, a building survey and economic analysis are vital to picking the most effective energy saving functions.

1. Bottom Line Program

In the interests of speed and accuracy, computer programs are commonly used to do this. These programs come in many stages of cost and sophistication. The "Bottom Line" program, for example, is a savings analysis that only requires a two page input by the building owner, ultimately resulting in a no-cost computer printout. In a little over two years, over 3,000 buildings have been analyzed and savings dollars printed. Bear in mind that this program deals in total dollar savings potential. A typical office building savings breakdown is shown below. Savings are expressed in dollars per year, per 1,000 square feet of floor area.

Control Point Reset	$126
Free Cooling	64
Scheduling HVAC Units	57
Demand Control	38
Set Cooling at 78°F	20
Lighting Control	34
Duty Cycling	17
Reduced Night Temperature	14
Reduce Heating Stats to 68°F	5
	$375 Per Year/1,000 Ft^2

2. Building Simulation

For more accurate determination, in advance, of "before and after" energy costs using different energy management schemes, a number of building simulation programs are available; they cost from $500 to $5,000, depending on complexity of the building and/or system simulated. They can be done rapidly, using actual weather data for any location, and virtually guarantee that the anticipated dollar savings will happen. A "zero energy band" simulation, for example, showed dramatic savings in a San Diego campus building just by locking out cooling and heating until space temperatures strayed outside the 68-78°F limits for heating and cooling.

C. SECOND CRITERION - CORRECT APPLICATION OF ENERGY MANAGEMENT FUNCTIONS

1. Building Management Systems

Most commercial buildings need an Energy Management System in some form. The Delta 1000, for example, is available either as an on-site owner operated system or as a paid service, called B.O.S.S. In the latter case, the console and 24-hour operating crew is in a central location. Phone lines connect to remote buildings, in many cases, 100 miles or more distant.

2. Flexibility is the key word for these systems. It is impossible to design, in advance, a perfect timetable for operating a school, a bank, an office, or a shopping center. The operator must be able to step in via keyboard to change schedules, allow for holidays, late occupancy, and the like.

3. Graphics by means of slides, or by means of color CRTs, can greatly assist operators when fast action is needed in response to a no heat, no cooling, or other abnormal occurrences.

4. Application of Energy Management "Modules"

Suppose a roof-top unit, for example, is to be connected to the Building Management System. Many questions must be answered before this equipment can operate in an efficient manner, such as:

(1) Are outside dampers tight?

(2) How much outside air is being brought in? How much is really needed?

(3) What is the nameplate fan horsepower? How many actual amps does it draw? What cfm is delivered? How much through hot deck? Cold deck?

(4) What is tonnage of the DX refrigeration machine?

(5) What is Btu input and output of the heating side?

(6) Can firing rate be reduced? Are combustion efficiency checks made regularly?

(7) Is there an "integrated economizer" sequence to make full use of outside air for cooling?

(8) What areas of the building are served, and when are they occupied?

Many similar questions must be asked before any energy management function is applied. Perhaps some energy management functions can best be done by temperature control retrofit.

5. Application of "Optimum Start and Stop"

A time clock can save energy. However, it doesn't make sense for a computer system, with all of its power, to slavishly start that roof-top unit at the same "worst case" time every day. Computer logic can look at outdoor and indoor temperatures and time of day and start each unit no earlier or later than necessary to pick up and handle the load.

6. Chiller Plants and other major HVAC components, such as fans, pumps, and air handlers are selected for design conditions. In El Paso, that means it must handle a summer load at 98 dry bulb, 64 wet bulb. Yet temperatures over 95°F occur only about 115 hours a year. The rest of the season, HVAC equipment can run part time or at part load.

7. Duty Cycling takes advantage of less than full load conditions and allows fans, pumps, and air handlers to be turned off 10 to 20 minutes out of each hour, saving both fan horsepower and outside air loads.

8. Demand Meters tell the power company what maximum load you used each month. Translating their demand charges into real demand savings requires good judgment and hard work — to find loads that can be turned off, for instance. It takes three kilowatts of load connected to the demand controller for every one kilowatt you want to reduce. Amount of dollars this will save can best be answered by the power company rep who handles your account.

9. Outdoor Air is the "big spender" of energy in many buildings. First, make sure it's not leaking in through windows, doors, and cracks. Then check codes and standards to see what is really needed. In an office building, you can get by with 5 to 10 cfm per person, perhaps less than one-fifth of the original design amount. Lastly, make sure you use outdoor air for cooling whenever it's at the right temperature. Even here in El Paso, there are hundreds of hours every cooling season where outside air can help, especially for buildings needing cooling 24 hours a day.

D. THIRD CRITERION - LOCAL SUPPORT

An Energy Management System is no better than the spare parts and skilled technicians that can keep it going year after year. That's why it's so important to have a vendor who has these facilities nearby, or has the ability to train a cadre of your own experts and re-train when they leave. We recommend your software be checked out and updated at least yearly to keep pace with building usage and energy cost changes.

E. FOURTH CRITERION IS MONTHLY AUDITING

No Energy Management System is good enough to work for you without a monthly check of your energy units and dollars. Techniques are now being developed so that, for the first time, energy units can be reconciled with building occupancy and outside weather conditions. Real costs avoided year-to-date and for this month can be accurately calculated, using outside weather records, such as degree hours of cooling <u>or</u> heating, plus an occupancy factor, which accounts for hours in use multiplied by thousands of square feet. Ultimately, this will allow Building A to be compared to Building B of the same type.

F. SUMMARY AND RECAP

In summary, we have reviewed four criteria or benchmarks that will help to select a sound, working Energy Management System. They are:

- Economics
- Correct Application
- Local Support
- Monthly Audits

Follow these guidelines and enjoy wise use of energy!

ENERGY CONSERVATION THROUGH CONTROLS DESIGN

By Joseph Paoluccio

I. Dead Band Control Strategy
   A. Prevents simultaneous heating and cooling
   B. Throttling Range (Acceptable Comfort Range)
      1. 10F with 68F minimum and 78F maximum
   C. Dead Band
      1. A portion of the throttling range during which neither heating nor cooling energy is used.
      2. 5F; 70.5F to 75.5F
   D. Space Demand Feedback
      1. Space temperature manages heating and cooling energy through prearranged sequencing.
   E. Space humidity is controlled on a high limit reset basis as a function of dry bulb temperature.
   F. See figure 1; Logic diagram
II. Dead Band Controls Guide Presents
   A. Step-by-step method for energy conservation through controls design guidelines.
   B. Engineering guidelines for Dead Band retrofit include:
      1. Logic diagrams
      2. System schematics
   C. Methods for estimating construction and maintenance costs
      1. Life cycle cost application
      2. Payback analysis application
      3. See Figures 3 and 4; Estimating Aids
III. Computer Modeling
   A. Computer modeling was used to predict relative energy consumption for buildings and control strategies addressed in the Dead Band Controls Guide
   B. Three representative climatic zones were analyzed
      1. San Diego, California
      2. Great Lakes, Illinois

3. Pensacola, Florida

C. Two types of building construction were analyzed

1. Heavy construction

2. Light construction

D. Relative Energy Consumption; See Figures 4, 5 and 6

E. References:

DEAD BAND CONTROLS GUIDE
Contract No. N68305-78-C-0011
Naval Construction Battalion Center
Port Hueneme, California 93043

HVAC CONTROLS GUIDE FOR ENERGY CONSERVATION
P.O. No. 77 MR 781
Naval Construction Battalion Center
Port Hueneme, California 93043

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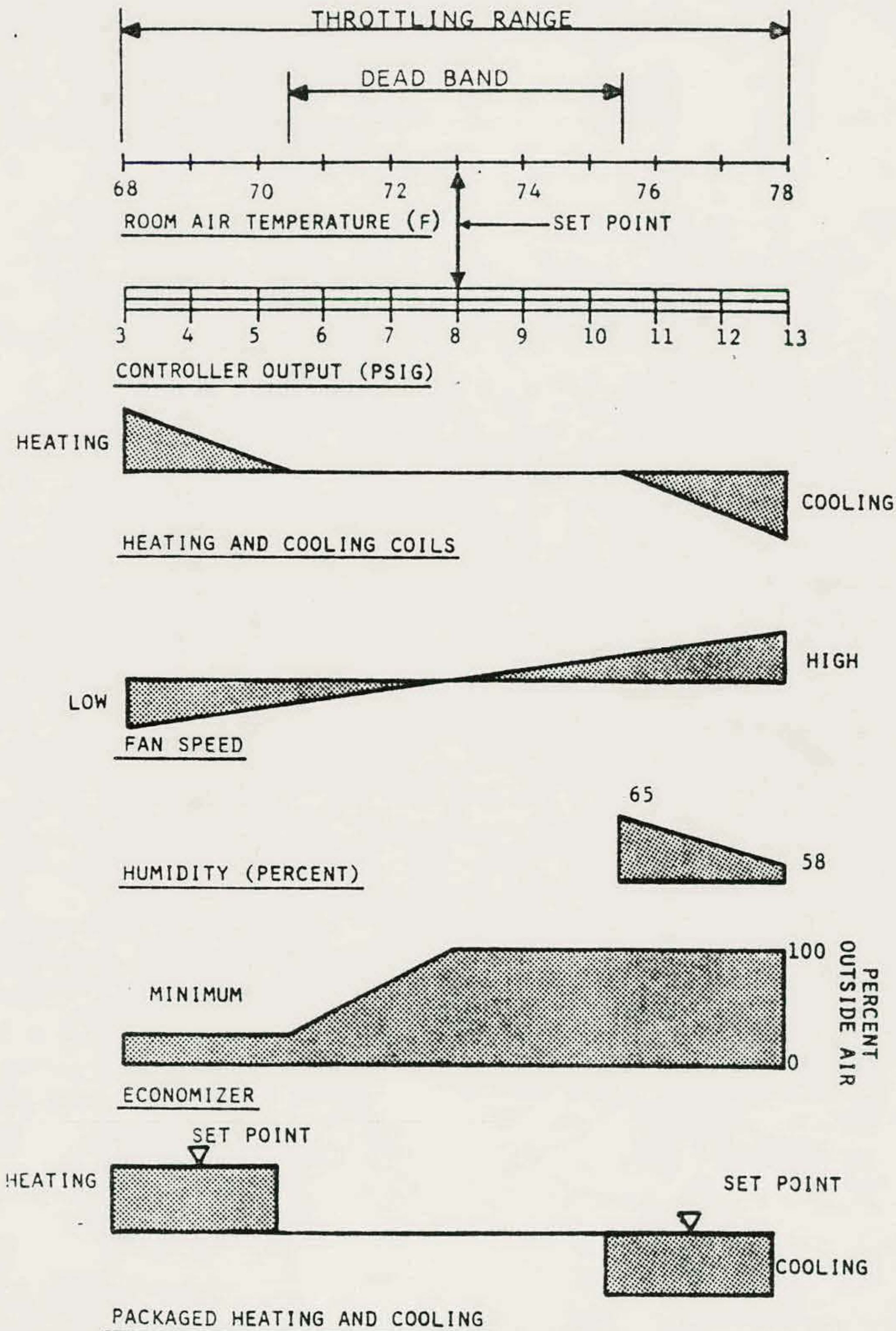
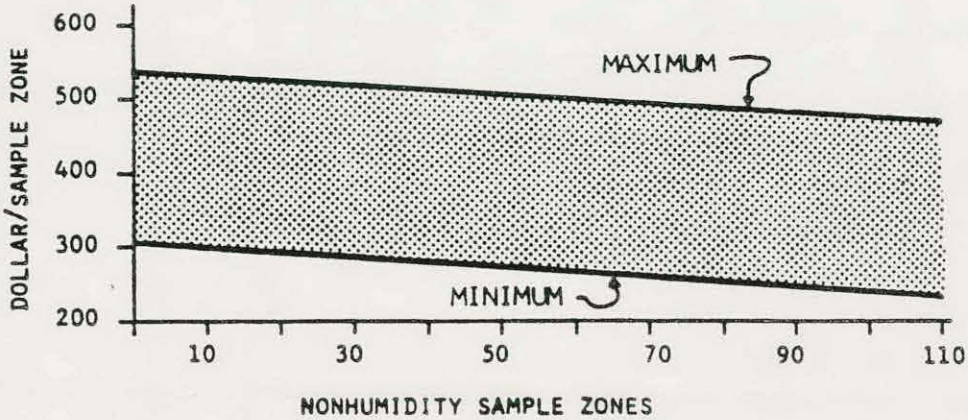


Figure 1. DEAD BAND LOGIC DIAGRAM



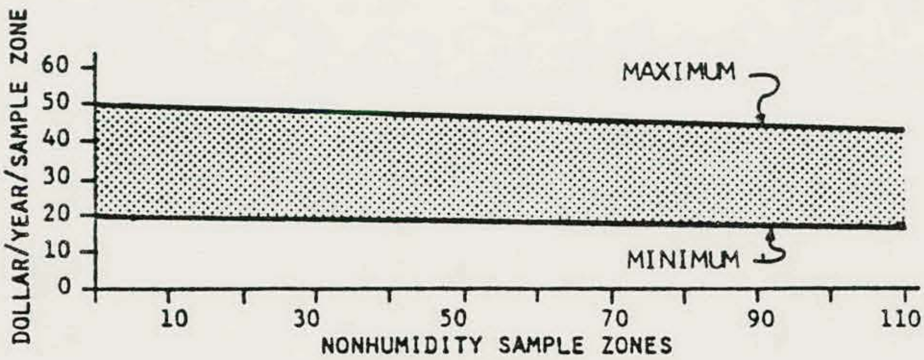
ZONE DATA:

________ NONSAMPLE ZONE(S)	X	20 $/EA	=	________
________ NONHUMIDITY SAMPLE ZONE(S)	X	____ $/EA	=	________
________ HUMIDITY SAMPLE ZONE(S)	X	600 $/EA	=	________

CENTRAL AIR HANDLING APPARATUS:

________ COOLING COIL(S)	X	400 $/EA	=	________
________ HEATING COIL(S)	X	400 $/EA	=	________
________ PREHEAT COIL(S)	X	400 $/EA	=	________
________ ECONOMIZER(S)	X	700 $/EA	=	________
________ CONTROL PANEL	X	250 $/EA	=	________
________ TUBING (FEET)	X	________		________
________ OTHER	X	________		________
________ OTHER	X	________		________
		SUBTOTAL	=	________
________ OVERHEAD	X ______ % ÷ 100		=	________
		SUBTOTAL	=	________
________ PROFIT	X ______ % ÷ 100		=	________
		TOTAL	=	________

Figure 2. INSTALLATION ESTIMATING AID



ZONE DATA:

______ NONSAMPLE ZONE(S)	X	0	$/YR	= ______
______ NONHUMIDITY SAMPLE ZONE(S)	X	______	$/YR	= ______
______ HUMIDITY SAMPLE ZONE(S)	X	70	$/YR	= ______

CENTRAL AIR HANDLING APPARATUS:

______ COOLING COIL(S)	X	25	$/YR	= ______
______ HEATING COIL(S)	X	25	$/YR	= ______
______ PREHEAT COIL(S)	X	25	$/YR	= ______
______ ECONOMIZER(S)	X	40	$/YR	= ______
______ OTHER	X	______	$/YR	= ______
______ OTHER	X	______	$/YR	= ______
			SUBTOTAL	= ______
______ OVERHEAD X ______ % ÷ 100				= ______
			SUBTOTAL	= ______
______ PROFIT X ______ % ÷ 100				= ______
			TOTAL	= ______

Figure 3. OPERATION AND MAINTENANCE ESTIMATING AID

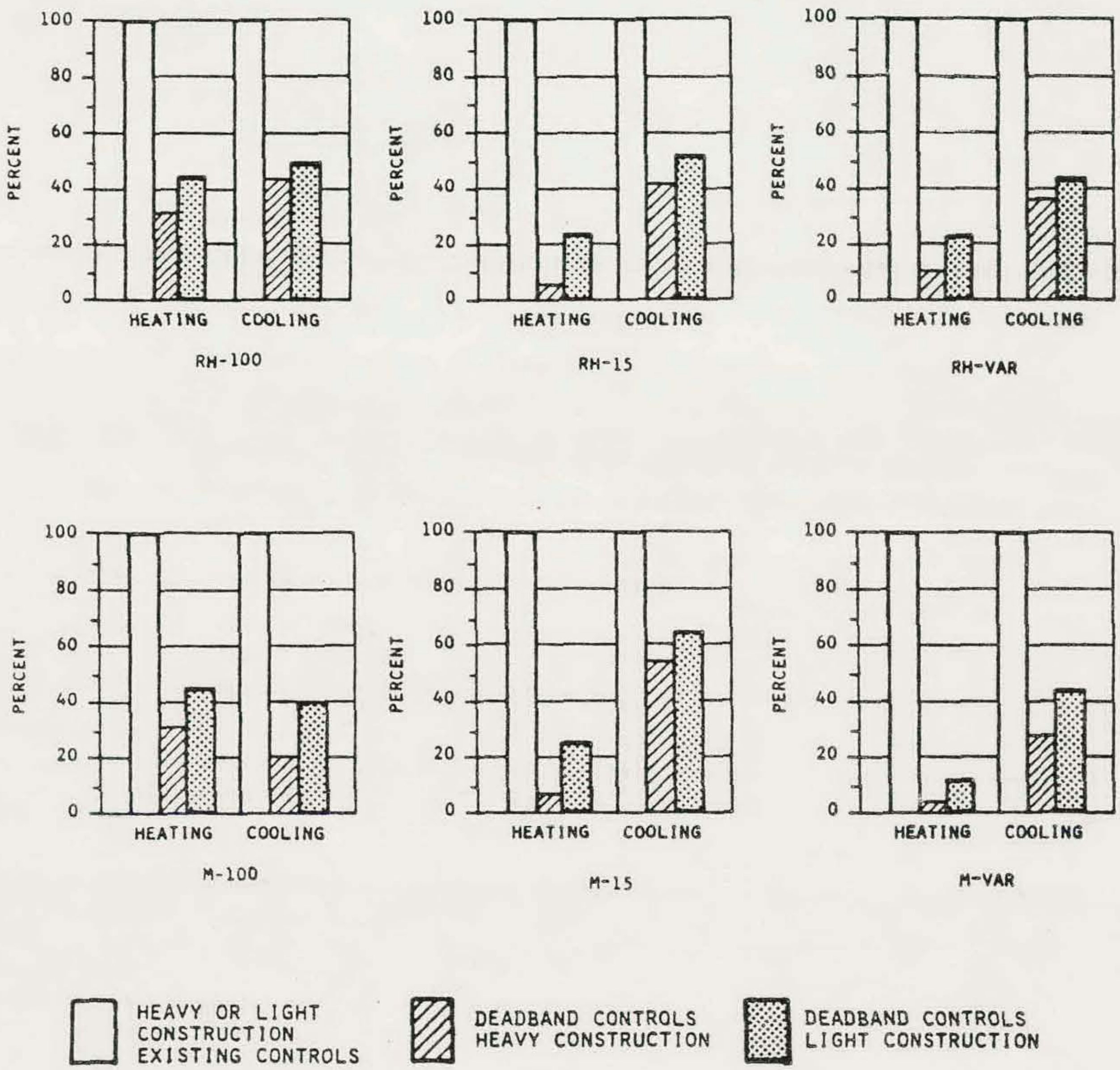


Figure 4. RELATIVE ENERGY CONSUMPTION - SAN DIEGO

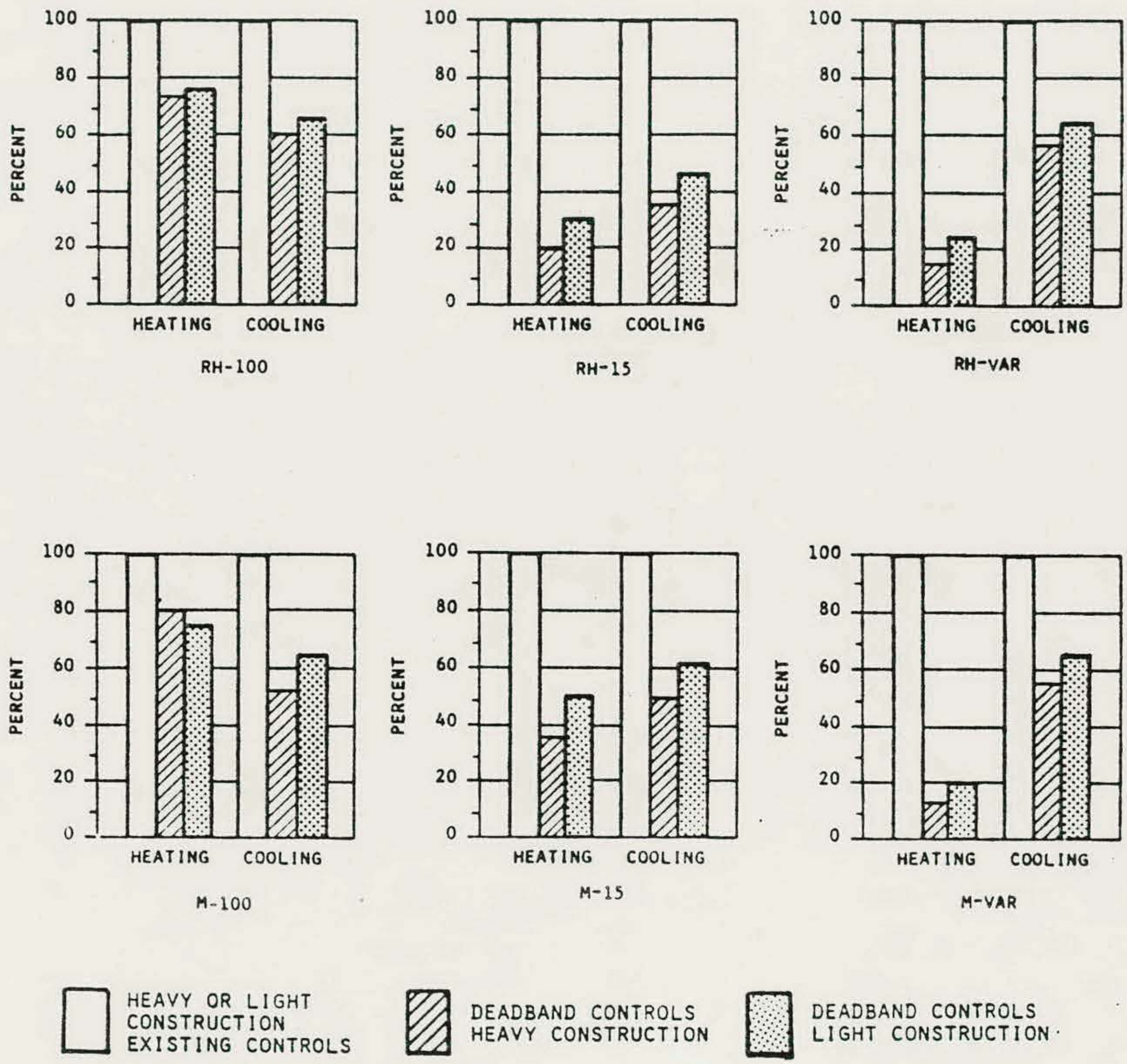


Figure 5. RELATIVE ENERGY CONSUMPTION - GREAT LAKES

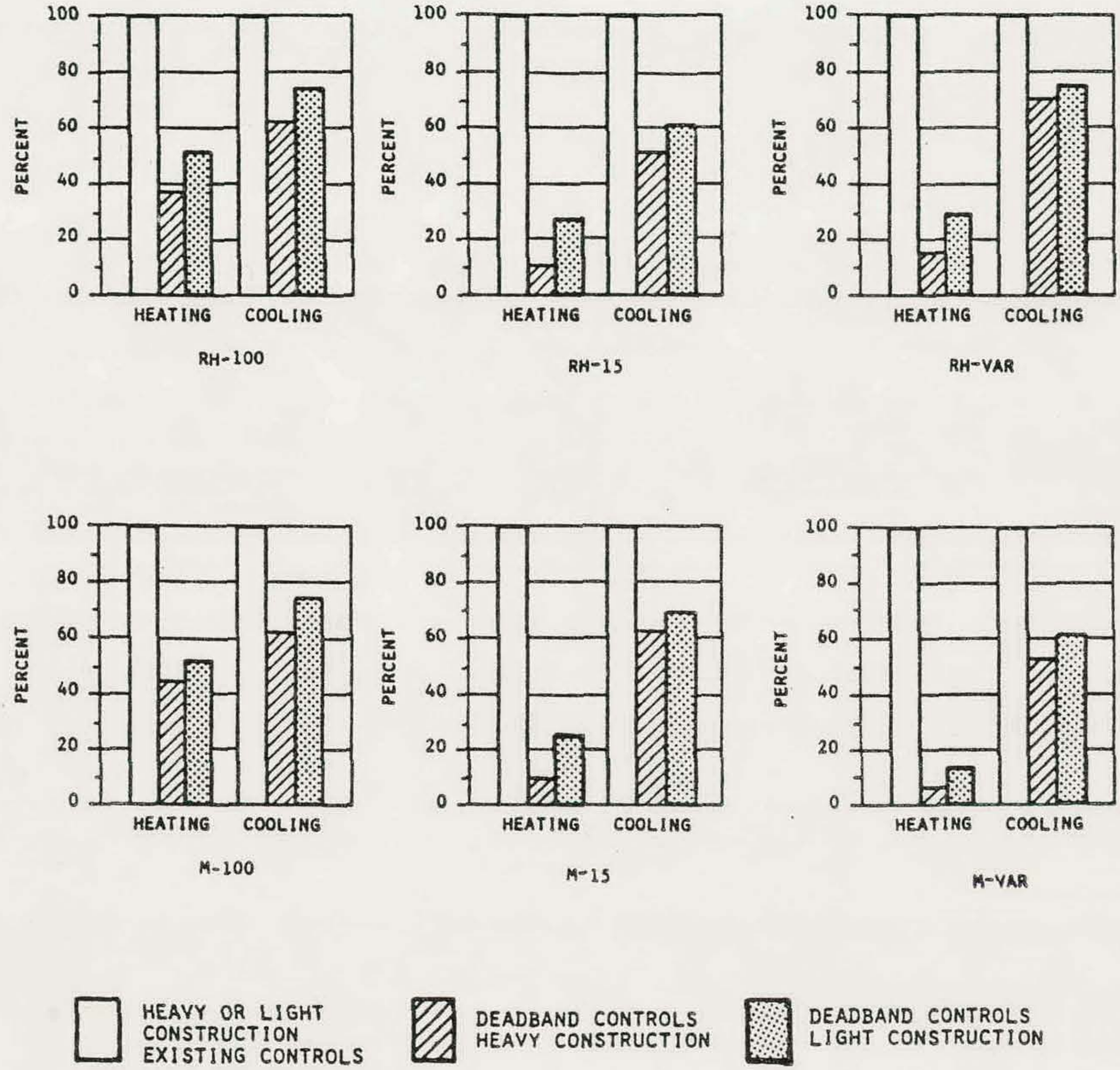
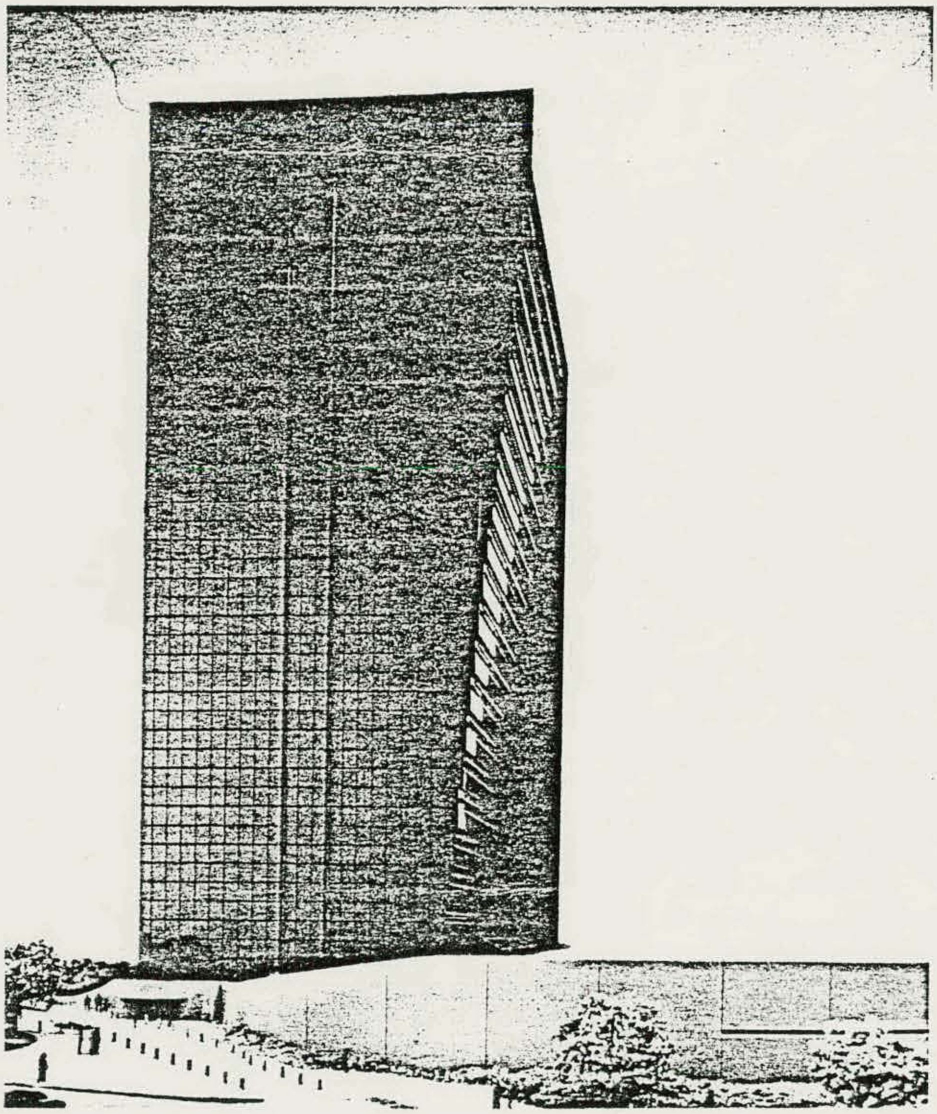


Figure 6. RELATIVE ENERGY CONSUMPTION - PENSACOLA

Case Study 26

By Larry Lord

PROJECT: Georgia Power Co. Corporate Headquarters, Atlanta, Ga.
ARCHITECT/ENGINEER: Heery & Heery Architects & Engineers Inc., Atlanta, Ga.



INTRODUCTION: The Georgia Power Company (GPC), a large and progressive utility serving the state of Georgia, had outgrown its original headquarters and decided to consolidate corporate operations in a new central office building in downtown Atlanta. The company retained Heery & Heery to study the programmatic needs for accomplishing consolidation and the following specific objectives:

- o reduce operating and administrative expenses by centralizing offices, and accommodate future growth;
- o contribute to the civic health and stability of Atlanta by remaining in the downtown area; and,
- o set an example of innovative, economical energy conservation design.

The architect's mission was to design an energy efficient building, satisfying the client's functional and budgetary criteria, that would not only achieve energy cost savings for GPC operations but would demonstrate the economic feasibility of energy conservation to its customers, the construction industry and the general public.

The design of a 24-story office tower and three-story, solar collector-crowned base provided a facility comparable in size, quality and cost to other Atlanta office buildings, but which was expected to consume 43 percent less energy than its average counterpart. A large scale, active solar collection system would further reduce purchased energy for heating and cooling, while special lighting equipment would minimize electrical demand.

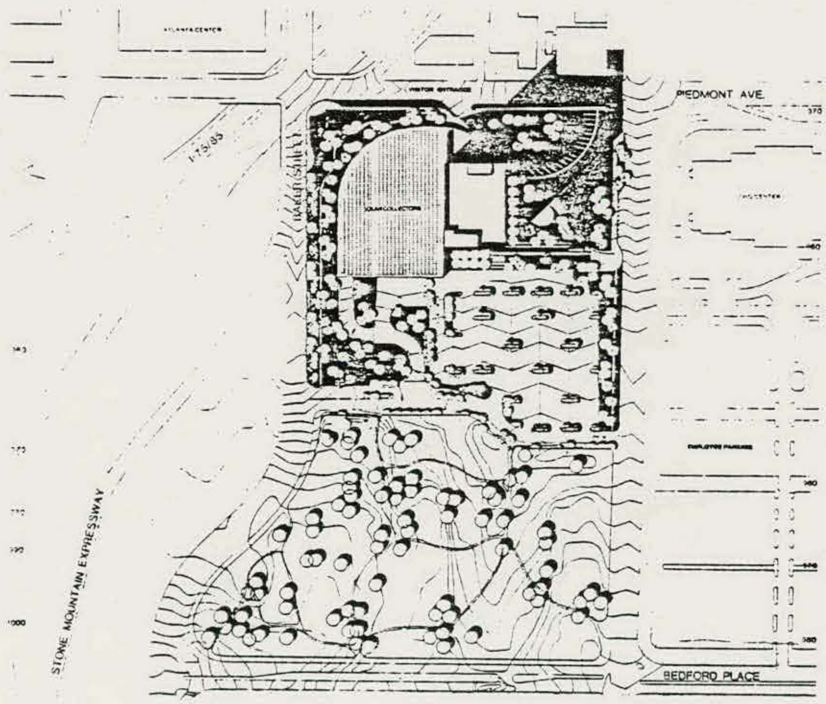
PROGRAM: In programming, which consisted of five major elements (space allocations and functional relationships, energy utilization and conservation, construction time and cost, site development, and design parameters), the architect used several techniques to identify influences on energy use and to determine potential energy demand and consumption.

	PEAK DEMAND (BTU/SF/HR) SUMMER	WINTER	CONSUMPTION (BTU/SQ.FT./YR)
No. of Buildings	31	31	31
Average	21.73	29.36	94,353.31
Maximum Peak Demand	34.64	62.57	150,092.72
Maximum Consumption	34.01	39.71	168,014.39
Minimum Summer Peak	14.08	18.78	66,963.81
Minimum Winter Peak	16.91	16.30	72.715.42
Minimum Annual Consumption	15.88	27.14	53,606.08
ENERGY BUDGET	14	16	51,000.00

Figure 1: Energy use by Atlanta buildings; GPC energy budget.

Energy Budget: Development of demand and consumption goals began with a survey of energy use in existing buildings of Atlanta. From a sample of more than 60, all applicable energy data was obtained on 31 of these high and mid-rise office buildings. Based on summaries of this data, a three-part energy budget for the GPC facility was established. It set design targets for summer and winter peak demands and for energy consumption, which were expressed in BTU's per gross square foot. The energy budget was the building's performance objective, considering all energy sources and uses appropriate to the building, and was used to evaluate design progress. Figure 1 shows energy survey summaries and the resulting energy budget for the GPC building.

Figure 2: Site plan for GPC facility.



Climate/Site: Analysis of the regional and site specific influence of climate showed, in summary, that although Atlanta's summe , are relatively warm and winters mild, heating degree days (65°F base) outnumber cooling degree days 2 to 1. ASHRAE 2.5% summer and winter design temperatures (dry bulb) are 92°F and 23°F, respectively.

Programming included analysis of the site conditions and related factors. The GPC facility was to be the first project in a redevelopment area adjacent to the city's central business district. The cleared site offered the opportunity to optimize siting, orientation, and public visibility. In addition, sun rights were assured by an interstate highway right-of-way immediately south and southeast of the site. Site layout is shown in Figure 2.

Space Standards: Space alone consumes no energy. However, the function performed in that space and the ability of the space to accommodate the function determine energy consumption. Space standards for individual tasks were developed, intergrating lighting level, comfort requirements, and equipment usage. The space studies identified the major groups of spaces and aided the architect in arranging functionally and energy efficient layouts.

Project Budget: Cost estimates were based on the client's desire to have a facility comparable to other corporate high rise office buildings in Atlanta. The architect's task was to accomplish energy conservation and other objectives within this budget limit. Meeting this criteria would fulfill another objective: to demonstrate the commercial viability of energy conservation design. The cost of special energy conservation features as public demonstrations, such as the solar collection system, were considered separate from the base budget.

DESIGN: The architect's procedure involved a series of design-evaluation steps, in which component designs were evaluated, redesigned and reevaluated until a satisfactory solution was reached. Manual and automated calculation procedures were used in evaluation and in measuring total building performance against energy budgets at various stages of design development.

The starting point of the process was a baseline design developed in response to the relative magnitudes of individual building load components (air distribution, heating, air conditioning, process loads, lighting). These had been identified from the energy survey of Atlanta office buildings conducted earlier.

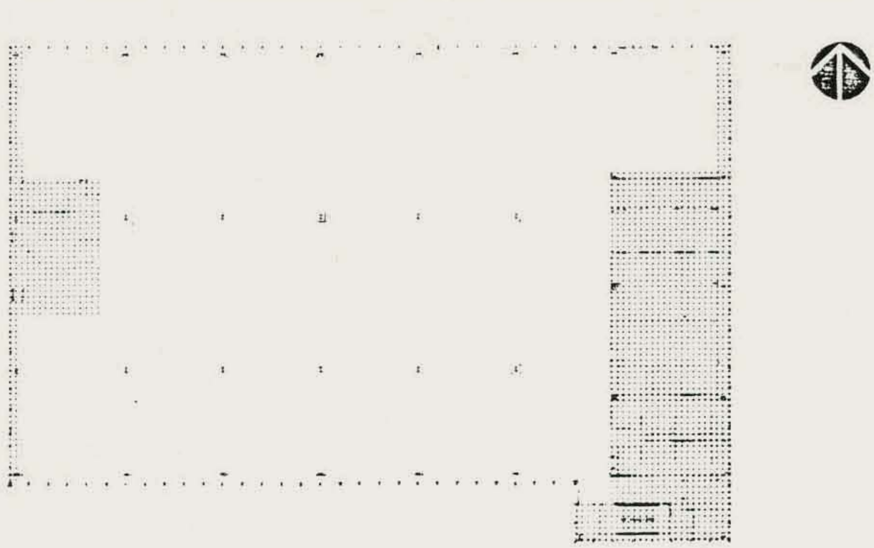
Energy Analysis: Numerous, detailed calculations were necessary in order to predict component and total energy performance and to measure them against energy budgets. A computer was used to simulate total building performance, while many manual calculations were made of specific component demands. A series of 175 computer-assisted simulations was produced. Each simulation identified "suspect" loads, which were altered through redesign before the next simulation. All computer inputs were handled by a single operator in order to control relative validity. A variety of computer programs were used in analysis, including TRACE, SCOUT, AXCESS, Southern Services, TRNSYS, and ECUBE. (See Tools/Techniques section of the Energy Notebook.)

Building Configuration: A total of 465,000 square feet of homogeneous office space was organized into a 24-story tower. Computer studies aided in energy analysis of 30 different tower forms. Although an atrium type scheme would have provided a three percent reduction in annual energy consumption, it was inadequate for planning office space layouts and did not satisfy the client's need for flexibility. The rectangle with an east-west axis and an aspect ratio of 1.6:1.0 was chosen as best meeting energy and other programmatic criteria.

A separate, three-story base was also designed. Enclosed by a curving, earth-bermed wall, this building would house 290,000 square feet of special facilities including GPC's Georgia Energy Center, the computerized load management center of the utility's entire power network. The more energy-intensive and 24 hour/day operations would be located in this building, which was designed to function independently of the office tower.

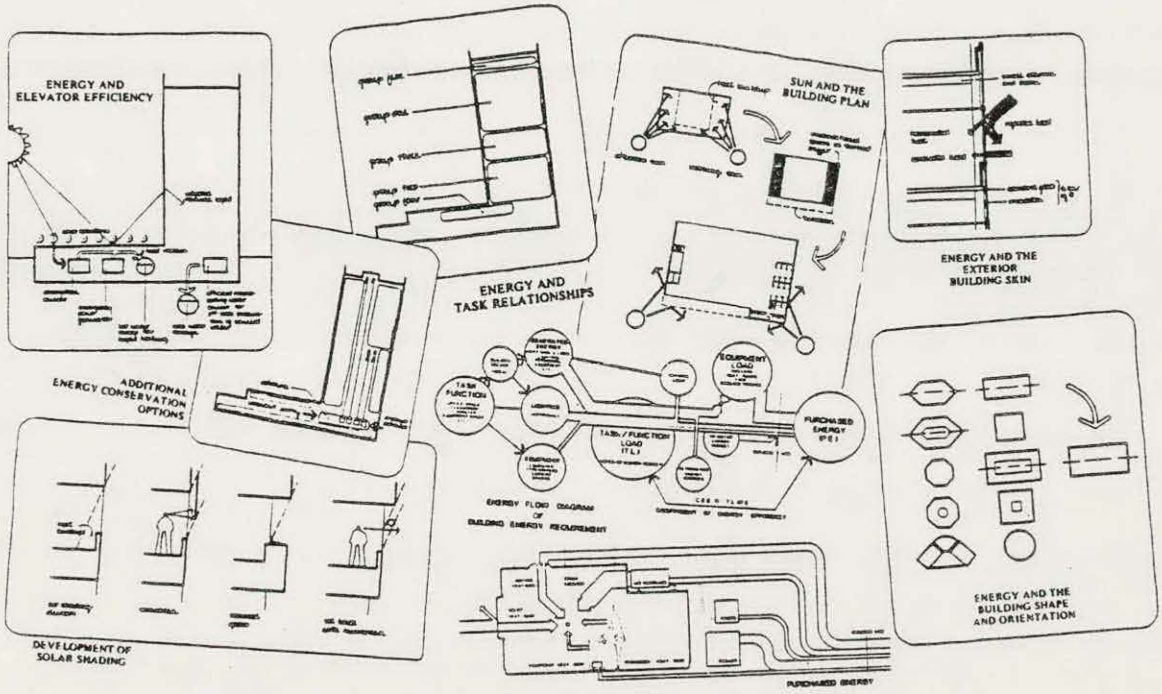
End Core: A unique feature of the design was the decision to locate service cores at the east and west ends of the tower building rather than to centralize the unoccupied spaces, elevators, stair towers, mechanical rooms, and storage rooms. The end cores added thermal buffering to the east and west walls, which consist of opaque, insulated, reflective spandrel glass. Computer simulations revealed that this combination reduced annual energy consumption 20 percent below that of a central core scheme combined with 50 percent vision glass on the east and west walls. The typical tower floor plan (Figure 3) shows the location of the end cores.

Figure 3: Typical tower floor plan showing east/west end cores.



Other Architectural Features: The esthetically unique south wall recedes in "steps" from top to bottom, creating a series of overhangs that, with sun-screens, shade the vision glass from direct solar radiation and reduce the cooling load. A variety of studies were performed of shading and other architectural considerations, which together proved to be the most significant single aspect in determining building energy performance. The design ideas generated are illustrated in Figure 4.

Figure 4: Energy design ideas generated for GPC facility.



Systems Design: Beyond the architectural treatment, equipment systems were developed using the design-evaluation process. This was especially effective in reducing building energy requirements in the case of lighting system design. The lighting scheme would consume only 1.65 Watts/s.f., which is 3 to 5 Watts less than the average Atlanta office building. A task-oriented, ceiling lighting arrangment was devised using 2x2 deep cell parabolic fluorescent fixtures. These would provide 60-70 ESI footcandles (Equivalent Spherical Illumination) to task locations. An open and semi-open office plan maximizes light distribution from the fixtures and takes advantage of natural light from the curtainwall.

In corridors, lounges and similar spaces, innovative High Pressure Sodium (HPS) lamps would be used. These ultra-long life, low wattage lamps provide effective, but extremely low, brightness. A hanging HPS fixture to replace the fluorescents in the open office areas was still being developed when the design was completed. The use of HPS illumination throughout the office tower would reduce the lighting load to less than 1.0 Watt/s.f. Additional savings are possible through interfacing lighting controls with the computerized building control system.

A Central Control Monitoring and Signal System (CCMS) would aid energy conservation in building operation. In addition to the conventional environmental control functions, the computerized CCMS would also:

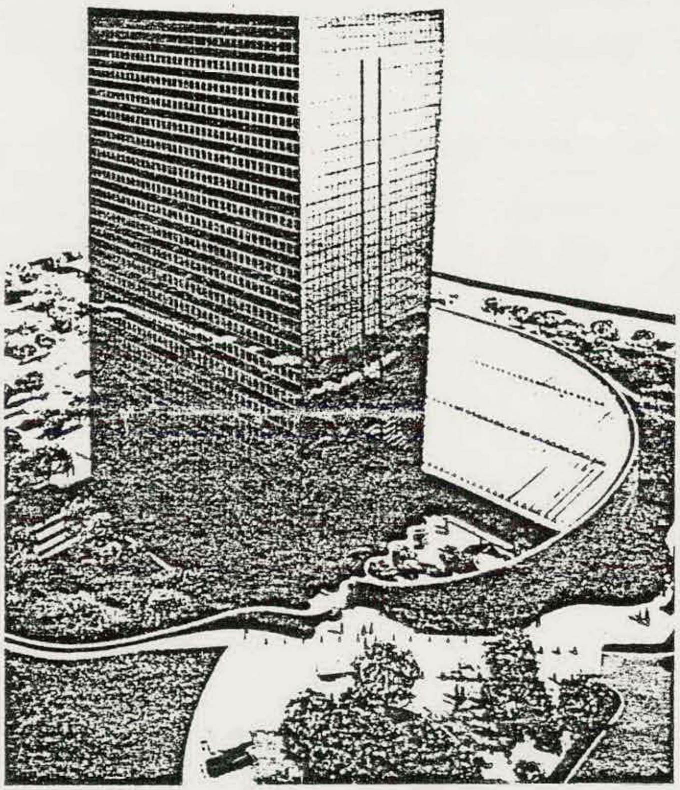
- optimize use of outside air for thermal comfort through continuous remote sensing and calculation of optimum enthalpy in operation of automatic dampers;
- precisely coordinate night shutdown and setback times by zones;
- adjust chilled water temperatures;
- start up equipment dynamically in response to exterior and interior space conditions and programmed occupancy times;
- selectively turn off lighting circuits in response to natural light available sensed by remote photoelectric cells.

ENERGY SYSTEM: Although energy requirements are greater in winter for Atlanta, the critical peak demand occurs in the summer. The reason is that winter heating can be supplied by natural gas and oil as well as by electricity, but high air conditioning needs in summer rely primarily on electricity alone. The usual way for an electric utility to satisfy peak demands is to generate more electricity by using older, inefficient power plants or by building new ones, passing the added costs on to custormer. GPC wanted to demonstrate in its own headquarters facility the opportunities for managing peak load through energy conservation. One of the most significant features of this project, chilled water storage, provided such a demonstration.

Cooling: Summer peak demand occurs at the coincidence of maximum environmental and internal heat gains. The GPC design minimized internal gains, primarily through efficient organization and systems design, as much as occupancy and client requirements permitted. Environmental heat gains from low sun angle, high insolation, and high ambient temperatures were controlled by the architectural features. The glazed building skin (80 percent insulated spandrel glass and 20 percent reflective insulating glass), end cores, and south wall setbacks and sunscreens helped lower peak demand as well as consumption.

Further peak leveling was accomplished by a 300,000-gallon chilled water storage tank incorporated in the building. Although it does not reduce energy consumption, the large volume of chilled water can carry the cooling load for three hours during peak demand. The chilled water is replenished at night, shifting the main chiller equipment load to off-peak hours. In addition, the cooling load of the building is handled by use of an outside air economizer when outside air temperatures are below 60°F.

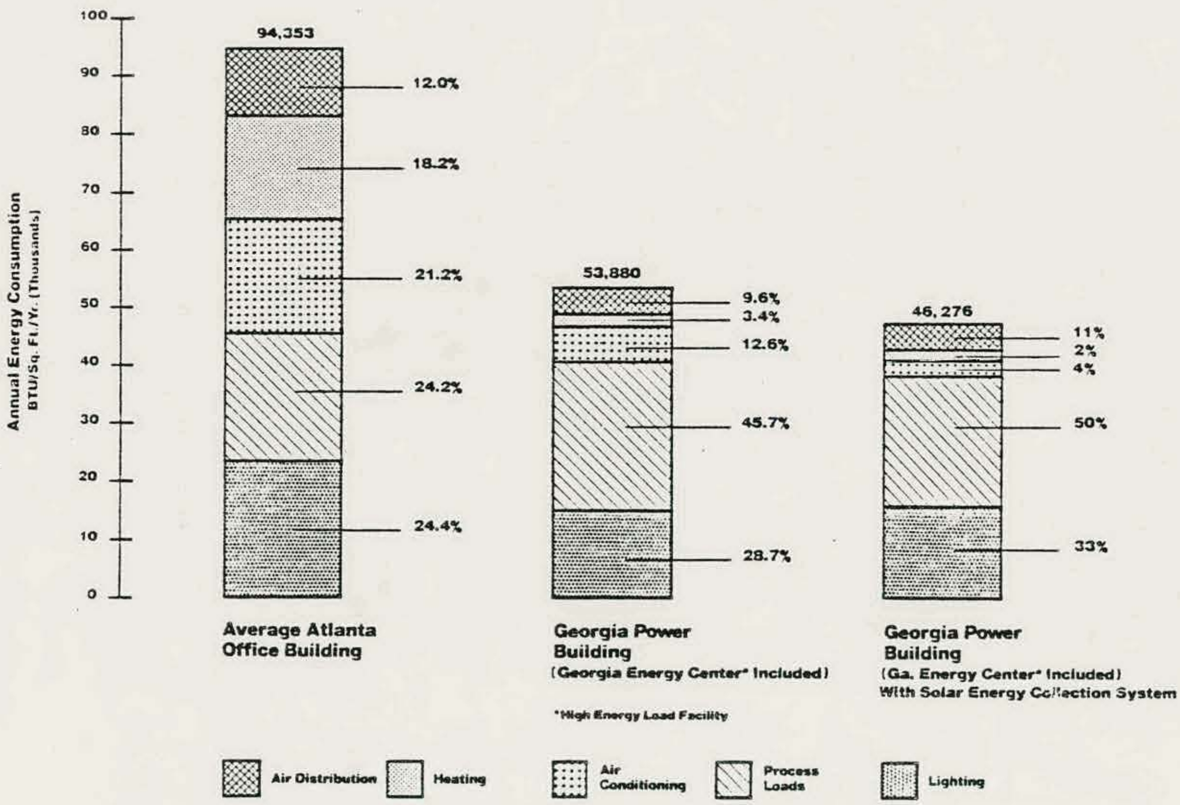
Heating: Internal gains from people, equipment, lights, etc. were considered more than adequate to heat the building during winter. A centrifugal chiller with a double bundle heat exchanger permits cooling of building zones with special equipment (such as computer operations, TV studio, printshop) while using the heat generated to supply heating zones. Peak demand is reduced by using hot water stored in two 25,000-gallon tanks for heating during peak periods and replenishing it during off-peak hours; an operation similar to water chilling. A conventional electric boiler provides backup heating.



Solar Collection System: Solar energy will supplement the building cooling, water heating and space heating through an active collection system positioned on the roof of the low-rise building. The system is designed to supply $5,617 \times 10^6$ BTU annually, or 14 percent of total energy requirements. The solar array consists of 1,485 concentrating parabolic trough collectors (each 2x8 feet) totaling 23,760 square feet of collector area. Computer analysis determined a cost-effective configuration, which is a combination of series and parallel circuits circulating a water and glycol heat transfer fluid. All internal components of the system are to be insulated, and a photoelectric sensor unit and automatic controls will operate the tracking array.

PREDICTED PERFORMANCE: Final preconstruction analysis estimated that building energy consumption would be 53,880 BTU/s.f./year, a 43 percent reduction from the 94,353 BTU/s.f./year of the average Atlanta office building. However, this was nearly 3,000 BTU/s.f./year above the project's

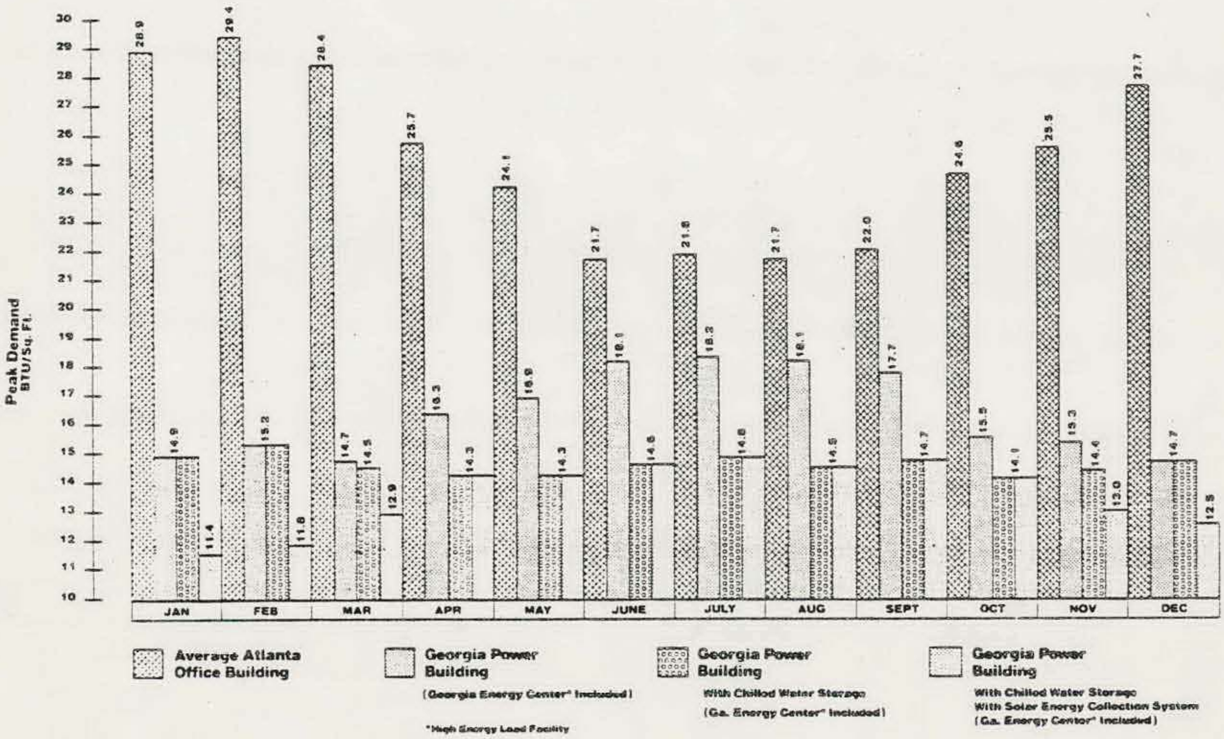
Figure 5: Energy consumption comparison by total and by load components.



energy budget of 51,000. Use of the solar collection system would drop annual consumption to 46,276 BTU/s.f., well below the energy budget. Another reduction to 42,000 BTU/s.f./year would be accomplished by adoption of the HPS lighting scheme. (See Figure 5 for energy consumption comparisons.)

Peak demand analysis showed that the design bettered the winter energy budget goal, but fell short of the summer peak goal even with the chilled water storage and solar energy systems. The graph in Figure 6 illustrates the inversion of the demand profile due to energy conservation and the flattening effect of chilled water storage. Collected solar energy further reduces winter peaks (of purchased energy), but only equals the effect of the chilled water storage on summer peak demand.

Figure 6: Peak demand comparison by month and by conservation feature.



Costs: Bids on the general contract were received, indicating the building cost of $37.6 million would be within the project budget. A separate performance specification was written for the design, furnishing and installation of the solar system and sent to 14 prospective suppliers. It required bidders to submit a fixed price for a guaranteed performance (energy output) of the solar collectors. Only three manufacturers responded with complete and meaningful proposals. The winning bid was $1,069,000. The total project cost demonstrated the ability to accurately estimate and procure an innovative, state-of-the-art energy conserving building within a budget comparable to other programmatically similar office buildings in the region.

PASSIVE SOLAR BUILDING PERFORMANCE
SOLAR TECHNICAL LIAISON DIVISION
SANDIA LABORATORIES
ALBUQUERQUE, N.M.

By

Robert P. Stromberg

Passive solar buildings, and the methods for their design, are coming of age. The Third National Passive Solar Conference took place in January at San Jose, Ca.; it had been one year since the Second National Passive Conference. At the Second Conference, a rather small amount of data was presented. There was a considerable amount of material showing the energy savings obtained. Things were different at the San Jose Conference. Many authors described their comfortable homes and buildings and showed actual temperature records for the winter of 1977-78. A husband and wife developer team described their project in Davis, Ca. with over 75 of the intended 200 passive solar homes sold. They had absolutely no problem in selling the rest as fast as they were built. They showed their solutions to dealing with planning and zoning officials, doing optimum street orientation for solar access as well as many interesting innovations to take care of solar rights and reduce overall energy needs.

Several persons presented alternative methods for design and construction of passive homes. There were various approaches for the "rule of thumb" guidance needed by the architect during the original conceptual design. Simplified calculation methods were available for the architect or engineer during the development stage of the project, and detailed calculation methods were available for "zeroing in" on a design during the definitive design stage. In summary, the design tools are becoming available for design of passive buildings with confidence in their performance when built.

Ms. Omi Walden, Assistant Secretary, Conservation and Solar Application, called passive solar design the major omission in the Department of Energy Solar Program, and said plans were made for a major emphases on passive design in the future. In a previously published report (Reference 1) five passive solar buildings were described along with their performance. These buildings, as well as some others with more up-to-date performance data, show the growth in this technology, both in performance and understanding.

REFERENCES

(1) R. P. Stromberg and S. O. Woodall, Passive Solar Buildings: A Compilation of Data and Results, Sandia Laboratories, Albuquerque, NM, Report No. SAND77-1204 (Revised).

MODERN COAL FIRED HIGH TEMPERATURE WATER (HTW) HEAT PLANT

By Bill Peavy and R. S. Karabensh

A. PROJECT IDENTIFICATION AND SCOPE

1. Location

Francis E. Warren Air Force Base is located just west of the town of Cheyenne in southern Wyoming.

This base was started as a military post for the cavalry and much of the architectural treatment of existing buildings has been preserved. The major portion of this project lies with a Wyoming historical boundary area.

2. Purpose

Pursuant to the National Energy Act to reduce the consumption of natural gas, Warren Air Force Base has been selected to change their fuel to coal for heating most of the major facilities.

With the completion of the newly designed heat plant and HTW distribution system to 111 buildings, much of the existing natural gas distribution system will be abandoned.

Start of construction for this project is scheduled for the first half of 1979.

3. Fuel

It is anticipated that Wyoming coal will be used at this facility and provisions have been made to receive coal by either railcar or trucks. Coal bunkers for "live" storage within the heat plant have been sized for a 4 day supply of coal at the maximum usage rate. The "dead" storage space provided is sufficient to hold a one year supply of coal.

4. Building Modifications

Of the 111 buildings to receive their primary heat source from the HTW distribution system, 44 buildings required modifications to the existing secondary heating systems. In most cases the secondary heating systems have been changed to hot water heat. This approach has provided a cost effective interface between the primary (HTW) and secondary (hot water) systems and has greatly increased the efficiency of the individual building heating system by reapportioning the heat distribution.

The remaining 67 buildings have secondary heating systems that are compatible for interfacing with HTW by installing either steam generators or hot water converter heat exchangers in the existing boiler rooms.

5. Energy Monitoring and Control System

An energy monitoring and control system (EMCS) has been provided to monitor the BTU consumption by measuring the temperature difference and flow of HTW through each building. When the outside air temperature reaches 65°F the building heating systems will be shut off by disabling the HTW pressure control valve or the hot water circulation pumps.

A control keyboard and CRT will be installed in the central heat plant to allow the operators to monitor the performance of the HTW system. A control keyboard, CRT, and printers will be installed in the central engineering office building. A report will be printed monthly stating the usage of HTW for each building on the system. It will also be possible to monitor HTW temperature and flow for individual buildings on an as-desired basis.

B. PLANT CAPACITY AND SYSTEM OPERATION

1. High Temperature Water Generators

Three identical vertical coal-fired high temperature water generators have been provided and located within the heat plant. The capacity of each generator is 55,000,000 BTU per hour which is 50% of the peak demand load for the HTW system. Two HTW generators are required to meet maximum operating conditions, the third being a standby unit. The plant peak demand load of 110,000,000 BTU per hour was determined as the sum of 80% diversified space heating load and 65% diversified utility heating load increased by plant use, estimated line loses, and a contingency factor.

The output capacity requirement for each HTW generator is 55,000,000 BTU per hour with 400°F outlet (supply) temperature and 264°F inlet (return) temperature which corresponds to the flow requirement of 386,643 LB/HR for each generator. The generators receive flow from, and discharge to, common headers.

2. Pumps

Three identical pumps have been provided with one being a standby unit. Each pump is sized to match the flow requirement of one generator which is 50% of the estimated peak flow demanded by the HTW system. A differential pressure controller in conjunction with two bypass control valves maintain a constant pressure difference across the HTW generator(s); thus, constant flow through the operating pump(s) and generator(s) is assured.

3. System Pressurization

HTW expansion tanks provide a reservoir for the pumps, a space for expansion and contraction of the high temperature water, and a volume for pressurization using a fixed quantity of nitrogen gas. Two tanks have been provided to accommodate expansion for the full range of operating conditions throughout the year. The tanks are connected to the HTW return line on the suction side of the pumps in such a manner as to minimize temperature and pressure fluctuations in the expansion tanks.

The pressurization with a fixed quantity of nitrogen gas keeps the system pressure above the vapor pressure of water at the generator outlet with consideration given to elevation and temperature difference within the HTW system. The maximum system pressure range at the pump outlet is 392-439 psig.

4. Distribution Piping

The HTW distribution piping to the building interfaces has been sized using maximum flows corresponding to maximum heating loads without diversification. Two separate zones have been provided, both of which receive flow from, and return flow to, common headers within the heat plant. Due to its longer length, Zone 1 piping is sized using reasonable velocities with consideration of pressure drops for pump horsepower requirement. Zone 2 piping and major branches of Zone 1 have been sized to achieve hydraulic balancing such that pressure drops at the ends of all major branches are within 15% of each other. Balancing valves are provided in the return lines of the two zones.

There is approximately eight and one-half miles of HTW distribution piping on this project.

C. MAJOR EQUIPMENT SELECTIONS

1. HTW vs. Steam

Since there are no facilities at Warren Air Force Base that require large quantities of high pressure steam, there are many advantages to employing a high temperature water system. In addition to basically being a less complex system, several advantages of a HTW system with respect to efficiency and economics are listed below.

a. HTW system requires less fuel consumption due to the elimination of:

1) Atmospheric steam flashing and handling of condensate.
2) Radiation losses at condensate and feedwater pumps, and leakage at valve stems and traps.
3) Continuous variation in firing rates due to sensitiveness of steam generators with changing load conditions. (Due to the large quantity of water that is flowing in a HTW system, a flywheel effect is produced which tends to absorb changing load conditions).

b. Some of the economic benefits of a HTW system are:

1) The elimination of pressure reducing stations, traps, condensate pumps, and receivers.
2) The requirements for water softener and feedwater chemical treatment is less for a HTW system than for a steam system.
3) The distribution supply lines are considerably smaller for water than for a steam system of equivalent capacity. Realizing that the HTW return line is larger than a condensate return line, one must remember that the condensate line also requires traps, receivers, valves, and pumps which cost more than the HTW return piping.

c. Maintenance requirements for a HTW system have proven to be less than for steam systems of equivalent capacities.

2. Wet Scrubbers vs. Precipitators vs. Baghouses

In selecting the pollution control equipment, both particulate and SO_2 removal had to be considered, even though the Wyoming coals to be used at Warren Air Force Base have a very low sulfur content.

Concerning particulate removal efficiencies for submicron sized particles, wet scrubbers are typically in the 90% efficiency range while precipitators above 98% are usual and baghouses may easily reach 99+%. However, in some cases, venturi scrubbers operating at high pressure drops (i.e. 25 in. H_2O) have been known to compete with baghouses and precipitators.

a. Wet Scrubbers

Regardless of the requirement for SO_2 removal, sulfur plays another part in firing fossil fuels. During combustion, sulfur combines with oxygen to make SO_2 and SO_3, which combine with water to form sulfurous and sulfuric acid. These acids can form directly in the gas stream below the water dewpoint, causing extreme corrosion in a wet scrubber and to a lesser degree in baghouses and precipitators. In addition, SO_2 removal has been obtained with scrubbers designed only for particulate removal. The result is an acidic bottom slurry which must be disposed of. Also, the requirement for slurry handling, settling ponds, significant water usage, and lesser operating efficiencies at reasonable pressure drops, have all contributed to the conclusion that a wet scrubber was not a feasible method for air pollution control for this project.

b. Electrostatic Precipitators

The use of electrostatic precipitation to remove fine particles from air is an old and proven method. The gas stream is exposed to a high voltage electrical field which charges the solid particles. These particles migrate to an oppositely charged collecting surface where they cling until removed by vibration. Proper functioning of an electrostatic precipitator requires that the resistivity of the fly ash be within a relatively narrow range. Difficulties staying in this range have been experienced with low sulfur fuels and hence these fuels are not conducive to high collection efficiencies. Consequently, precipitators have not been selected for use on this project.

c. Baghouses

The application of baghouses to coal fired generators is becoming increasingly necessary as tighter and tighter particulate regulations are applied. When burning low sulfur coal and maintaining a flue gas outlet temperature below 500°F, baghouses represent a less expensive and more efficient solution to the particulate problem.

Virtually any source of particulate emission may be controlled by a baghouse. Typically, baghouses are employed to control particulate emissions when a high collection efficiency on small particles is required. Efficiencies of 99.9+% are common and since baghouses are mechanical devices, their performance is not as sensitive to variations in load and fly ash properties, as, for example, with a precipitator.

The most critical design consideration for using a baghouse is the flue gas temperature. A too high temperature, continuously above 550°F, will damage the fiberglass bags and a too low temperature, below 300°F conservatively or below the sulfuric acid dewpoint will condense acid on the baghouse internals and cause considerable damage. The present system design, which incorporates the use of a baghouse, dictates a 467°F flue gas exit temperature from the generator, so both conditions are safely satisfied.

3. Coal Handling Equipment

The coal is delivered to the heat plant by belt conveyors where it is transferred to a bucket elevator. From this bucket elevator the coal is transferred to a dust-tight conveyor above the top of the three "live" storage bunkers for distribution into any bunker. The coal flows from the bunkers to a coal scale, then through non-segregating coal chutes to the stoker hoppers of the HTW generators.

An under bunker conveyor has been employed to provide the capability to feed any generator through its associated scale from any bunker; plus providing for coal to be taken from any bunker and delivered to the inlet of the elevator and returned to the same or any other bunker for the purpose of recirculating the coal to prevent heat build-up due to prolonged storage.

D. ENVIRONMENTAL CONSIDERATIONS

1. Fugitive Dust

   In addition to the installation of a baghouse as discussed previously, all outside coal conveyors have been provided with covers and the coal pile will be treated with an asphaltic sealer to prevent fugitive dust emissions.

2. Evaporation Ponds

   Two evaporation ponds have been provided to prevent any possible contamination of nearby streams. All blowdown and backwash water from the heat plant and all drainage from the coal pile area is piped to these ponds for evaporation.

3. Esthetic Considerations

   Since the HTW distribution piping on this project lies within a Wyoming historical boundary area, no above ground piping has been allowed. The distribution piping has been placed in trenches with concrete walls and covers. The trench is under existing sidewalks. Where sidewalks did not exist, they have been created with this installation.

   There are also numerous construction, maintenance and economic advantages to the concrete trench system.

E. CONCLUSION

With the installation of the high temperature water system at Warren Air Force Base, the need for approximately 400,000,000 cubic feet of natural gas per year will be obviated.

This is an energy conscious installation that is also in compliance with Federal, State and local environmental regulations.

UNITED STATES AIR FORCE MODEL BASE PROGRAM
A DOE/DOD ENERGY SHOWCASE INITIATIVE
FOR McCLELLAN AFB, CALIFORNIA

by

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Wright-Patterson Air Force Base, Ohio

UNITED STATES AIR FORCE MODEL BASE PROGRAM
A DOE/DOD ENERGY SHOWCASE INITIATIVE
FOR McCLELLAN AFB, CALIFORNIA

A. INTRODUCTION

The Energy Showcase Initiative is the result of joint actions by the Department of Energy (DOE) and the Department of Defense (DOD) to provide a technical display which will give high visibility to applications of advanced energy resource management procedures and selected new energy supply and conservation measures. The desired outcome is to provide both information and stimulation in these energy initiative areas to industry, Government and researchers, Congress, and the general public.

A primary showcase base has been selected for each military service in such a manner that the bases are located near centers of population in each of the western, eastern, and central parts of the United States.

The support of the installation and intermediate commanders, a pattern of success for new or innovative activities, compatible base mission, and physical layout were criteria also considered during the selection process. As a result of the above factors, McClellan Air Force Base, California, is the Department of the Air Force's primary energy showcase base, and can be viewed as a model base.

The McClellan AFB DOE/DOD Energy Showcase Initiative program described in this paper includes use of a full range of energy conservation technology and alternate energy sources, an estimate of the benefits accrued by DOE and DOD, and the management organization necessary to accomplish the program fully. The program is conceptual in form; however, the concept is fully explained and all known Energy Showcase Initiative requirements are met.

One specific objective is to identify and recommend those technologies and/or energy source uses that can be fully applied to satisfy McClellan AFB's energy needs. The various requirements considered were logistics, overall possible mission impact, operation/maintenance implications, and management procedures for long-term use. The existing base modernization and expansion plans, force readiness considerations, the current and future manning situation and command and base level management abilities were all considered in the development of the plan to assure that no technology or system would be recommended that would adversely impact McClellan.

In short, the initiative is designed to fit as perfectly as possible into McClellan's developing long-range energy use plan while providing a demonstration avenue which can stimulate technology growth and give operational visibility to industry, Government, the R&D community, and the general public.

A brief description of McClellan AFB follows.

The mission performed by the Sacramento Air Logistics Center (ALC) is twofold in nature. First, Sacramento ALC has worldwide logistic management responsibilities for assigned weapon systems, equipment, and commodity items. Second, it also performs an industrial-type mission in providing maintenance, supply and procurement-type services essential to Air Force logistics. The base's civilian and military strength totals over 17,000 personnel who work in the many activities located on its 3687 acres, with 894 buildings. The installation is the State of California's fourth largest employer with a payroll cost of $287 million in Fiscal Year (FY) 1977. Additionally, the base awarded contracts totaling more than $568 million in FY 77.

Sacramento ALC currently serves as System Manager (SM) for the following aircraft: F-111, FB-111, F-105, F-106, F-100, F-104, T-33, T-39, A-10, C-12, F-86, and the F-84;

in addition to eight missile and space programs, and 24 electronic systems.

McClellan AFB is host to the Air Logistics Center and seven major tenant organizations.

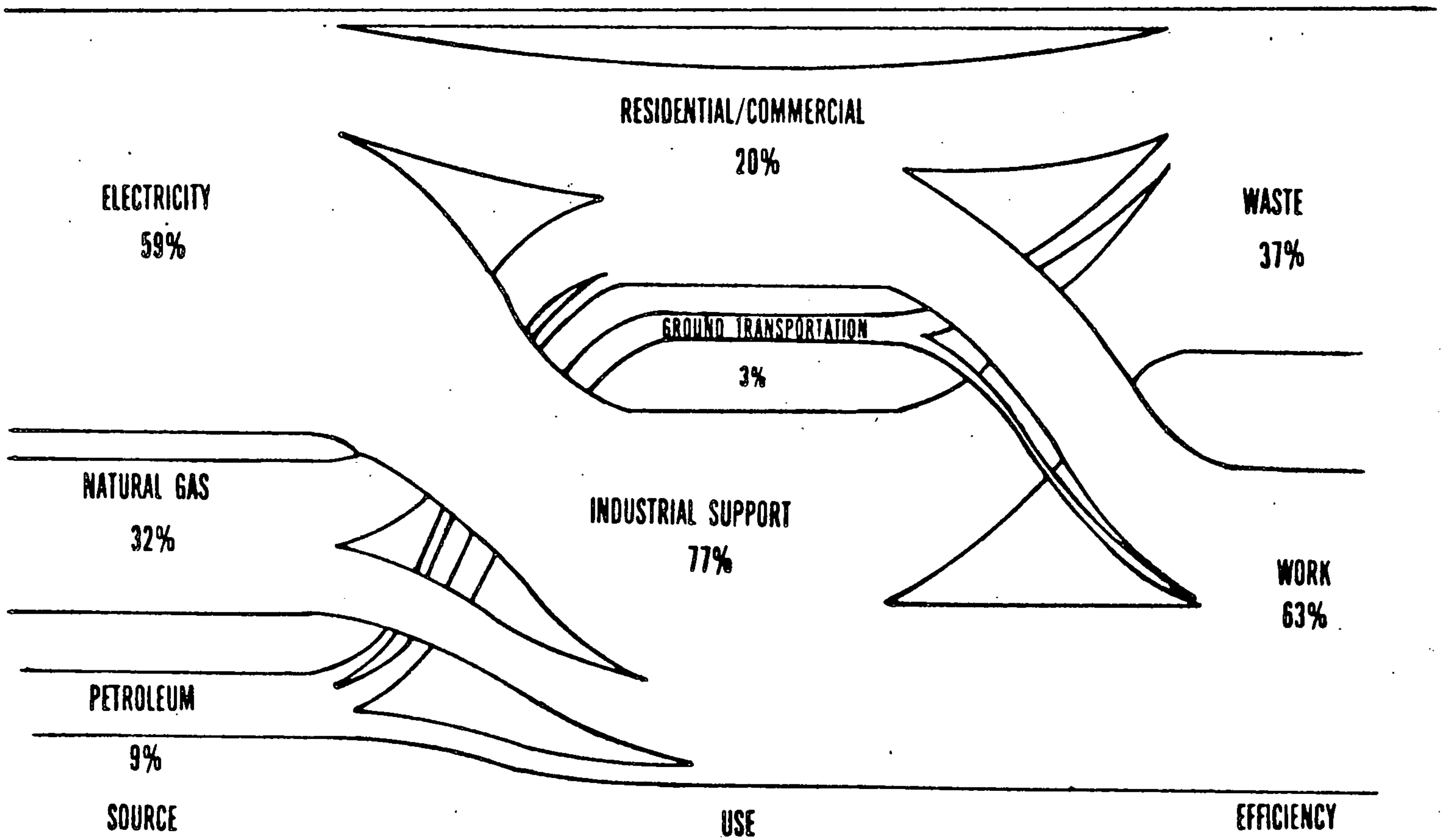
This paper will describe the current and projected energy use pattern on which the Showcase Initiative proposals are based. It will also identify those current and emerging energy technologies that were reviewed in order to select and define the proposed technology applications suitable to McClellan AFB.

B. CURRENT AND FUTURE ENERGY USE

Determination of the applicable energy technologies and/or sources required that the current pattern of energy use on McClellan AFB be established. This necessitated a review of historical energy consumption data, with emphasis on the data most recently available and an attempt to determine the current levels of consumption. Energy consumption showed electrical use to range between 9,600 and 10,800 MW hours per month, with peaks in January and July. Natural gas use is greatest during the winter months of November through February, peaking at about 138,000 MBTU and corresponding closely with the heating degree day curve. A conserted conservation effort is dramatically reflected in both the electrical and natural gas/fuel oil consumption figures between 1972 and 1977/78.

In addition to total levels of energy consumption, estimates were made of the energy flow within the base boundaries to indicate where and how energy is being used. The general flow diagram developed for McClellan is shown in Figure 1. Knowledge of the annual and monthly energy consumption patterns, and determination of the peak energy demands, as well as the hourly and daily variation in energy requirements, were important factors in evaluating the applicability of the possible alternative energy sources at this base. This data allowed

McCLELLAN ENERGY FLOW DIAGRAM



selection of the energy technology and source that was most effective for each use.

The energy requirements for McClellan were projected to the year 2000 in order to assess the impact of full use of both energy conservation technologies and alternate energy sources.

The projection was developed assuming all applicable energy technologies and sources are used to the fullest possible extent, that fuel availability is adequate for future growth, and that current energy usage patterns continue. Based on this projection, energy consumption can be expected to decrease by about 20% over the next 20 years. It must be emphasized that achievement of the projection will require funding for energy saving construction/facility retrofit projects in accordance with the developing long-term energy plan for McClellan. The objective of the long-term plan is to reduce reliance on foreign energy sources to the greatest extent possible for our industrial energy needs by the year 2000.

In the following section, those current and emerging energy technologies considered during the development of the showcase concept are reviewed.

C. TECHNOLOGIES CONSIDERED

The areas considered for initiative implementation were broken into two large groups, Energy Conservation Technologies and Alternate Energy Sources. The first covers the range of systems/designs capable of conserving energy derived from existing sources, and the second covers the use of energy sources other than what is currently consumed at McClellan. The data gathered by the Air Force Terrestrial Energy Study(1) was utilized in deciding what technologies and sources would most probably be useful to McClellan. This enabled a number of technologies/sources to be eliminated from consideration without the need for formal evaluation. For example, McClellan is not situated over a geothermal resource region or where ocean thermal or tidal power potential exists; therefore, these technologies do not apply. However, application of solar technologies is very feasible as the Annual Mean Daily Irradiance received ranges from 1500 to 1800 $BTU/FT^2/Yr$. The areas outlined in Table I were reviewed to determine those of potential use to McClellan.

TABLE I

Energy Technologies/Sources

1. Energy Conservation Technologies
    a. Utilities Centralization
    b. Energy Management and Control
    c. Industrial Processes
    d. Building Envelope
    e. Building Environmental Control Systems
2. Alternate Energy Sources
    a. Chemical
    b. Nuclear
    c. Solar
    d. Geothermal
    e. Refuse/Biomass

The following parameters were considered in evaluating and selecting those technologies best suited for McClellan:

TABLE II

Evaluation Parameters

1. Energy Conservation
    a. Availability of systems
    b. High energy use facility/industrial process
    c. Diversity of facilities considered
    d. Available space for systems

e. Available energy source for systems

f. Diversity of systems

g. Potential economic payback of systems

2. Alternate Energy Sources

a. Geography

b. Logistics

c. Space available for storage

d. Specific building location/surroundings

e. Potential economic payback of use

Based on evaluation, using the above parameters, specific applications described in the next section were recommended for inclusion in the McClellan DOE/DOD Energy Showcase Initiative.

D. PROPOSED TECHNOLOGY APPLICATIONS

The proposed technology applications will be briefly described in three groups. The first group pertains to techniques to conserve the use of existing energy sources. The second group applies new alternate sources of energy. Lastly, a group is provided for a number of additional methods which do not fall readily into the above categories. This group also provides a means for adding other applications not previously considered if they are determined worthwhile.

1. Energy Conservation Technologies

a. Utilities Centralization. Under this area, two different categories apply; one for centralization of utilities for a large number of facilities and a second for centralization of utilities for individual facilities. The two are not mutually exclusive on a large, diversified base, and they can actually be complementary if developed correctly.

Total base utilities centralization takes into account the overall energy flow of a base and satisfies as much of it as possible by using a large central plant rather than a number of small, dispersed plants. This takes advantage of efficiency of scale (large boilers, compressors, etc., are more efficient to operate than small ones) and non-seasonal use, the possibility of cogeneration (using the waste energy from one process to operate another), and energy flow control (switching from one type of energy use to another at appropriate times to reduce peak loads).

Individual facility utilities centralization (building energy systems) has the advantage of providing reliable on-site power at a minimum energy cost. This concept, on a small scale, has all of the features of total base centralization, and is particularly useful for facilities which must have an uninterrupted energy flow. Examples of this type of facility include computer systems, communications centers, and command posts. Incorporated with a total base central utilities network, centralized individual facility systems can provide reliable power to essential facilities at the lowest energy cost.

Based on evaluation of many possible combinations of both central and distributed utilities systems, the following offered the best mix of technologies at minimum energy use and are recommended for inclusion in the Showcase Initiatives Program: (1) Centralize all appropriate base utilities (i.e., thermal energy, chilled water, compressed air) into one or more plants and (2) for four selected facilities, provide individual building total energy systems using base-wide distribution system(s) as backup. The following paragraphs outline the concepts.

b. Utilities Centralization. This initiative consists of centralizing all base utilities into one or more large plants. The method and amount of centralization (one or several plants; all utilities or just a few) must be explored during a full scale feasibility study, as any centralization is highly dependent upon total energy flow and the load profiles of a particular application. The method and amount of centralization must also be established before any firm decision can be made concerning the number or type of plants, the siting of those plants or even the type of utility to be addressed.

The feasibility study for this initiative should also consider the possibility of cogeneration of electricity, use of refuse derived fuel or biomass as a primary or supplemental fuel, and the practicality/constraints involved in construction by the Air Force with operation and maintenance by the local utility company (Sacramento Utility District (SMUD)). Other possible combinations of ownership and operation should also be explored with the advantages and disadvantages of each clearly detailed. SMUD has expressed interest in a cogeneration program with McClellan. Discussions held with the SMUD staff indicate they are amenable to various combinations of ownership and co-production of steam and electricity. They have already entered into one cogeneration arrangement with a local firm. SMUD officials are aware of current DOD policy against entering into competition with utility companies.

Each utility to be centralized will require a distribution system. Up to four distribution systems could be required (thermal, chilled water, compressed air and electrical). Each system is expected to utilize existing lines/pipes where possible.

Each utility centralization recommendation could require replacement of many existing pieces of equipment. The following examples illustrate this point. A thermal energy plant could possibly replace four large boilers, 125-150 individual building boilers, and approximately 200 individual space heaters. A refrigeration plant could possibly replace five major units and a large number of individual building chillers. A compressor plant could possibly replace five major units and a large number of individual building compressors.

The energy savings inherent in these centralizations are estimated to be 20% of the energy consumed by the existing dispersed equipment. This percentage translates into an annual energy savings of 0.3 to 0.4 million MBTU/year. It is impossible to estimate cost savings at this time; however, studies of similar central plants for other DOD installations have shown payback periods of 20 to 25 years. If this holds true for this plant, the yearly cost savings would be in the range of $2.60 to $3.25 million per year.

In addition to the energy-cost savings aspects, this initiative will enable DOD/DOE to judge the value of various types of advanced combustion techniques in industrial applications. Due to the stringent environmental restrictions in the State of California, it will be necessary to employ advanced combustion techniques/technology in order to reduce emissions from any central plant(s).

c. <u>Individual Building Energy Systems</u>. Four facilities are recommended for individual energy systems. The type of systems evaluated for these facilities are fuel cells, Stirling engines, and improved diesel engines. The USAF Terrestrial Energy Study[(1)] has shown that these systems have the most promise for general USAF use and that they can replace existing

USAF backup power systems on a one-for-one basis. Total energy requirements (all thermal and electrical) are to be furnished by the proposed units to the maximum extent possible.

Building 200 is principally an administrative facility for the ALC and contains the ALC Command Post. The Command Post and other selected portions of the building are the only areas anticipated being attached to the energy system at this time. The power requirements are on the order of 300 KWp and 5.0 MBTU/hour. The fuel cell was chosen as the best system for this application, and it is recommended that it be configured to operate on natural gas/liquid petroleum.

Building 262 is the main computer facility for the ALC. The total building electrical and environmental control systems are to be provided by the proposed energy system. The power required is on the order of 1720 KWp and 1.0 MBTU/hour. The improved diesel engine with heat recovery was found to be optimum for this facility. The recommended concept is for this diesel system to be configured to run off as many different fuels as possible with a minimum of modifications.

The Stirling engine system was found to be useful for Building 7, the base Communications Center. The total power required to operate the facility is on the order of 2000 KWp and 2 MBTU/hour. It is proposed that the Stirling engine system will generate one third (1/3) of the total load and be configured for multi-fuel use with the primary fuel being liquid petroleum. The possible fuel alternates include natural gas, coal, solid waste, and wood.

The last facility is Building 1099, the Radar Approach Control (RAPCON) facility. The total power required to operate the facility is on the order of 150 KWp and 1.0 MBTU/hour. The fuel cell system has also been determined to be best for this use. It is recommended that the fuel cell be configured to use liquid petroleum as the primary fuel with the capability of converting to natural gas use should liquid petroleum become unavailable. It is possible that some excess thermal energy could be provided to several nearby facilities.

The above four facilities were selected because they provide a highly visible, diversified use of small complete energy systems. In addition, they are representative of such facilities throughout the DOD and the private sector. Equally important to the DOD is that these facility systems will demonstrate the potential for use as remote-site power systems. Failure of the power supply at any of the selected type of facilities will substantially impair mission capability. An important factor in maintaining force readiness is the assurance that assigned power systems can provide an uninterrupted energy flow that is suitable for remote and mission critical installation applications. Individual building total energy systems offer a significant increase in energy flow reliability.

d. Energy Monitoring and Control. Energy Monitoring and Control Systems (EMCS) are computerized central control systems designed to optimize energy consumption on the base. For McClellan, it is recommended that the existing EMCS system be extended to include all energy intensive facilities on the base, and that it be tied into both building environmental control systems and industrial processes housed therein. The energy conservation functions available through the use of an extended EMCS system are substantial. Additionally, to validate the use of the technologies/sources and to provide the maximum amount of usable data, it is imperative to establish a reliable and extensive current energy use data base. To do this, it is necessary to install an extensive metering system on existing facilities/industrial process lines as soon as possible. If this is not done, validation of energy or cost savings will be impossible. It is also necessary that all new systems be connected to the base EMCS system for data monitoring and equipment control in order to provide the required operational data appropriate to each initiative. Expansion of the EMCS system as described will provide:

(1) A central data gathering/control point for all initiatives with the exception that control of any large central/regional utility plant will be data-linked to the base-wide EMCS for monitoring and data recording purposes only.

(2) A highly visible central point for describing the initiative program to visitors without disruption to on-going operations.

(3) An on-line system capable of real-time data reduction producing both visual displays and hard copies.

It is of interest to note that at McClellan, EMCS signals are transmitted over hardwire (coaxial cable and telephone pair) lines. The capability for transmission of signals by radio frequency is also employed.

There are literally millions of buildings and thousands of installations and industrial parks that can benefit from application of this type of system. This Showcase application will enable the technology to be visually displayed to its best advantage and should greatly enhance public knowledge and acceptance.

e. <u>Building System</u>. This category covers energy conservation technologies encompassing the building envelope, environmental control systems, and industrial processes. In this area, ways of improving the existing base assets through retrofit of upgraded or more efficient designs, systems, and/or processes were examined. The governing parameters in the selection of buildings to examine for improvements under this category were:

(1) Large energy users

(2) Diversity of energy use

(3) Range of possible technology applications

(4) Potential for general USAF application of demonstrated design, system, and/or process.

(5) Ease of retrofit of equipment

Use of these parameters resulted in selection of the following facilities:

(1) Building 200 - ALC Headquarters (Administrative building)

(2) Building 243D - Foundry

(3) Building 243G - Plating Shop

(4) Building 251 - High Bay Periodic Depot Maintenance Facility

(5) Building 362 - Final Cell Dock

(6) Building 365 - Final Cell Dock

(7) Building 692 - Aircraft Paint Hangar

(8) Building 783 - Automated Warehouse/Storage

As intended, these buildings cover a wide variety of energy conservation needs and, consequently, can effectively use a wide range of energy conservation technologies. Possible technologies range from electricity generation by use of waste heat to improved insulation. A matrix of a few possible energy conservation technologies is shown in Table III. The selection of specific technologies to be applied was not undertaken since a detailed A&E feasibility study covering the scope of the entire concept plan is necessary to properly examine the numerous interfaces involved. Use of the results from an on-going Base Energy Audit Program and other prior studies as appropriate is also envisioned during the feasibility study phase.

TABLE III

POSSIBLE ENERGY CONSERVATION TECHNOLOGIES

INDUSTRIAL PROCESS	BUILDING ENVIRONMENT CONTROL	BUILDING ENVELOPE
Waste Heat Recovery	Waste Heat Recovery	----------
Insulation (Process Flow, Tanks, Etc.)	Insulation (Ducting, Pipes, Etc.)	Insulation (Walls, Roofs, Etc.)
Thermal Storage	Thermal Storage	Thermal Storage
Upgraded Lighting	-----------	Upgraded Lighting
Change Energy Source	Change Energy Source	----------
Automatic Controls	Automatic Controls	----------
Equipment Upgrading	Equipment Upgrading	Material Upgrading
Better Process System	Better System Design	Better Building Design
Waste Material Recovery	-----------	----------
Energy Management	Energy Management	----------

Since these facilities are similar to a substantial segment of commercial sector facilities, the visibility of the varied technologies should dramatically increase public knowledge about an application of these improvements in equipment/designs.

2. Alternate Energy Sources

a. Potential alternate energy sources applicable to McClellan:

(1) Nuclear
(2) Refuse/Biomass
(3) Chemical (coal and synthetic fuels)
(4) Solar

The use of nuclear energy is not recommended due to the physical layout of the base, the current sentiment against its use at this time, and the uncertainty of the fuel source at this time. The use of refuse derived fuel or biomass appears to be a possibility for future use in the central plant(s) and is being considered under the developing long-range industrial energy plan. Based on evaluation of each potential source, the recommended primary energy sources at McClellan include coal, supplemented by the use of natural gas, liquid petroleum, synthetic fuels and solar energy. The applicable alternative or reduced energy source use locations recommended in this plan are described below.

b. Coal. The recommended centralization (see paragraph D1a) of utilities could use coal as a primary fuel if a large plant is determined to be optimum. If so, a large part of the current natural gas/electricity/liquid petroleum use would be replaced. This substitution would not only lessen the use of scarce natural gas and petroleum products, but would also lessen McClellan's vulnerability to an energy supply disruption.

c. Current Sources. If a single large plant is not optimum for McClellan, various advanced combustion techniques/ technologies could be used to improve the efficiency of smaller plants using natural gas or petroleum products as primary fuel. These techniques/technologies could significantly reduce the usage of such fuels without impairing mission effectiveness.

d. Solar Energy. There are many methods of converting incident solar radiation into useful energy. Of these methods, three are recommended for use at McClellan; photovoltaic cells, solar thermal units (both active and passive), and wind generators.

(1) Photovoltaic Systems. Cathodic protection for selected tanks, an underground gas line, and an electroplating facility power system are the recommended uses for photovoltaic cell systems. The cathodic protection systems are to be direct replacements for existing systems. The proposed facilities include:

(a) Water Tower #769 - 100 Watts Peak (Wp)
(b) Water Tower #233 - 20 Wp
(c) Water Tower #216 - 550 Wp
(d) Water Tower (Capehart) - 10 Wp
(e) Deluge Tank #705 - 10 Wp
(f) Underground Gas Line #65 - 450 Wp

To assure high visibility of the applied technology, it is suggested that the photovoltaic arrays be situated between the structure supports or on the sides of the tanks.

The most encompassing application of a photovoltaic power system is on the base electroplating facility, Building 243G. This facility uses a great deal of direct current (DC) electricity (to be provided directly from photovoltaic arrays) and low temperature water. The low temperature water can be provided as a by-product of actively cooling the arrays. This application can therefore use approximately 60% of the incident solar energy, as opposed to 6-10% in a normal application. It is expected that this system will reduce commercial utility electricity use at this facility by 25.0% and natural gas use by 50.0%. An additional advantage is that this energy, being supplied by the sun, will be greatest when the electrical energy use on base is highest. The proposed system will therefore have an electrical energy cost reduction far out of proportion to its actual energy production. This type of system has many other applications both within DOD and in the public sector.

(2) Solar Thermal Systems. The solar thermal applications were chosen to display a wide variety of technology. The family housing units, both on base and Capehart, can use both active and/or passive systems for space heating/cooling and domestic hot water. The dormitories, Buildings 521 and 522, can use both active and passive systems for space heating and hot water. The industrial facility, Building 692, can use an active system for process air heating. The selection of specific systems to be applied and the facilities involved is to be accomplished in the first phase of program implementation (feasibility study).

(3) Wind Systems. The wind use potential at McClellan is believed limited to two off-base communications sites. Specific site data was not available, but limited observation indicates that approximately one-third (700 KW) of the 2000 KW required by the off-base Davis Communication Annex and the total 200 KW required by the off-base Lincoln Communication Annex can be supplied by a wind system. Since no selection

of specific systems has been attempted, applicability of wind generators to on-base sites should be evaluated during the feasibility study.

The use of solar energy systems directly benefits McClellan in two ways. First, there is an overall reduction in energy use since solar energy has replaced electricity and/or natural gas. Secondly, and more important from a cost standpoint, the maximum energy is delivered at a time of peak use of electricity and natural gas, thus reducing the demand charge significantly. These applications are typical of similar situations throughout the DOD, and the public and private sectors. Their successful demonstration should encourage adoption in a variety of ways within and outside the Federal Government.

3. Miscellaneous Initiatives. It is anticipated that some small, yet highly effective initiatives might have been overlooked or may emerge subsequent to the preparation of the concept plan. Therefore, a miscellaneous area is provided to enable the program managers to include such initiatives in the overall plan at a later date. Examples of this type application include:

- Pneumatic, radio activated programmable circuit breaker panels
- Radio switched night setback controllers
- Radio signal controlled heating thermostats
- Transient voltage suppression on distribution lines
- Telephone dialed restart of EMCS switched interior lighting systems
- Infrared photographic analysis of electrical and heating distribution systems
- Spray irrigation of roofs to reduce environmental loads

Chilled brine storage systems
Daylighting techniques to use natural light
Stationary and/or movable window/door shading systems
Diurnal environmental enhancement systems
Electronic fluorescence lighting ballast
EMCS signal transmission over base electrical distribution system

E. OVERALL TECHNOLOGY IMPACT

The numerous current and emerging technology applications proposed for inclusion in the Energy Showcase Base Initiative provide a wide diversity, both in types of technology and in selection of different facility uses. A minimum of 15 distinct applications in the major technology groups is proposed. The locations of these applications are sited to give across-the-base coverage involving administrative, industrial, aircraft operations, communications, computer services, and personnel housing. Visibility and access to the application sites by a variety of interested groups were key considerations in the selection of the proposed projects. Additionally, provisions have been made to collect and document the operational, energy consumption, and cost data that are necessary to assess the value of the proposed applications to the target populations.

F. PROGRAM MANAGEMENT AND IMPLEMENTATION

Obviously, a program of the scope described above cannot be accomplished without an effective management organization and a thoroughly thought out implementation plan. A streamlined organizational structure has been developed to manage the program from concept through design, construction, testing, and operation. The revised structure is designed to focus appropriate management attention on the program to keep it moving. The organization also includes advisors from the regulatory and technical fields, both from within and outside the Federal Government. Advisory inputs are desired at both the headquarters and McClellan program committee working levels.

The concept plan detailing the proposed program describes an extensive implementation outline. It was designed to focus attention on several important milestones, the first of which has been completed. The Department of Energy gave their verbal concept approval during a briefing to them on 19 October 1978.

Another important item is the employment of an Architect-Engineer firm to conduct a detailed feasibility study of the concept plan. Action to select the A-E firm is underway. The feasibility study may be developed in several phases to accommodate on-going programming and design activities associated with the centralization portion of this initiative. It will validate and/or modify the proposed concept in order to take better advantage of existing facility/energy requirement conditions or the application of the most promising emerging technologies available at that point in time. In addition to the above, the following specific actions will be accomplished by the study:

- Analysis of utility loads/requirements
- Evaluation of changing shift hours on central plant loading
- Validation of Base Energy Audit Program (BEAP) computations for buildings over 30,000 SF in area
- Continuation of BEAP analysis for facilities less than 30,000 SF in size
- Evaluation of impact on on-going functional activities and interfaces required for operations for minimal disruption
- Time phasing for programming actions in view of current state of the art for each technology

Time phasing for construction

Validation/development of program costs to the start of construction

Preparation of initial environmental assessment

The length of the design and construction phases depends on the outcome of the feasibility study and the level of funding provided. However, it is anticipated that there will be some overlapping of the design, construction, testing, and operational phases due to the many distinct projects involved.

G. CONCLUSION

This paper only highlights the scope and expected benefits of the joint DOE/DOD Energy Showcase Initiative. It should be clear that although it proposes a multitude of technology applications, the program is comprehensive and fully interfaced with the on-going and planned energy activities at McClellan AFB. It satisfies all of the known objectives of the Departments of Energy and Defense. It is involved, but the Air Force believes it is workable. All who have been associated with the development of the concept are enthusiastic about it, are optimistic about its success, and are anxious to proceed to design and implementation of the projects.

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Title

1. USAF Terrestrial Energy Study, AF Aero Propulsion Laboratory, Air Force Systems Command, Wright-Patterson AFB, Ohio 45433 (AFAPL-TR-78-19, Volumes I-III, April 1978).

THE GRAND SCHEME/AN ECONOMIST'S VIEW
OF ENERGY CONSERVATION

By Rosalie Ruegg

OUTLINE

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C. WHAT PROBLEMS IN ENERGY CONSERVATION CAN ECONOMICS HELP SOLVE?

D. AN EXAMPLE

THE GRAND SCHEME/AN ECONOMIST'S VIEW OF ENERGY CONSERVATION

A. INTRODUCTION

In the letter inviting me to participate in this conference, economics was described as the web which can tie together the diverse elements present at this gathering of government policy makers and representatives of public utilities, architectural/engineering firms, manufacturers of energy conserving devices, and buyers, users, and practitioners of energy conservation. "Web," I trust, refers in this case to a network of related concerns that interconnect the various parties involved in energy conservation.

My purpose is to give an overview of the role economics can play in energy conservation. Let us begin by discussing the approach an economist takes to energy conservation, and then see how economics can help designers, engineers, builders, manufacturers, public utilities, policy makers, and consumers solve specific kinds of problems. I will conclude with a brief example of economics applied to solve a problem of mutual concern to designers, builders, and consumers.

B. HOW DOES AN ECONOMIST LOOK AT ENERGY CONSERVATION?

A central concern of economics is the efficient allocation of scarce resources. This means getting the largest possible benefit from available resources. It is from the standpoint of economic efficiency that economists usually view energy conservation. Because energy conservation, like energy consumption, generally requires the use of scarce resources, the economics problem is to determine in any given case if it pays to substitute scarce resources of one type (conservation) for scarce resources of another type (energy). Where energy can be conserved with little cost in terms of resources or sacrifices in human comfort or in productivity, it, or course, pays to do so. But where the costs of reducing energy consumption are sizable, an explicit comparison of the costs and benefits of energy conservation may be necessary to determine what kinds and how much conservation is economically efficient.

Since, in addition to conserving energy, it is possible to substitute renewable energy (e.g., solar energy) for nonrenewable energy (e.g., oil or gas) the problem is enlarged to finding how much it pays to use of each of the various alternatives to nonrenewable energy. This means finding the balance that will meet a desired objective, such as providing a given level of physical comfort or powering a given level of production, at the lowest cost. That balance occurs when an additional dollar spent on each of the types of energy conservation, on renewable energy, and on nonrenewable energy yields the same dollar value, and that dollar value is as great as that available at the margin on the best alternative investment. If the tradeoffs are properly made, net benefits--the difference between total benefits and total costs--will be maximized and the net total costs related to an energy objective will be minimized.

Figures 1a, 1b, and 1c illustrate a simple two-way tradeoff between conservation and energy consumption. The top figure, 1a, shows that energy consumption costs fall as energy conservation costs rise, such that total energy-related costs may first fall and then rise. "Qc" designates the level of energy conservation that results in the lowest total combined cost of energy and conservation.

The middle figure, 1b, shows that this same level of energy conservation, "Qc," maximizes net benefits to energy conservation. That is, Figures 2a and 2b are two ways of looking at the same thing.

The bottom figure, 1c, shows that the optimal level of conservation occurs where the last dollar spent on conservation yields exactly a dollar of savings, i.e., where marginal costs equal marginal savings.

Figure 2 extends Figure 1 and shows a simple three-way comparison among renewable energy, nonrenewable energy, and energy conservation. The lower two solid curves show a tradeoff between renewable and nonrenewable energy, such as heating by oil versus solar energy. The top solid curve shows the total combined cost of the two energy sources based on a given level of energy conservation.

FIGURE 1

FIG. 1a LEVEL OF ENERGY CONSERVATION THAT MINIMIZES TOTAL ENERGY RELATED COSTS

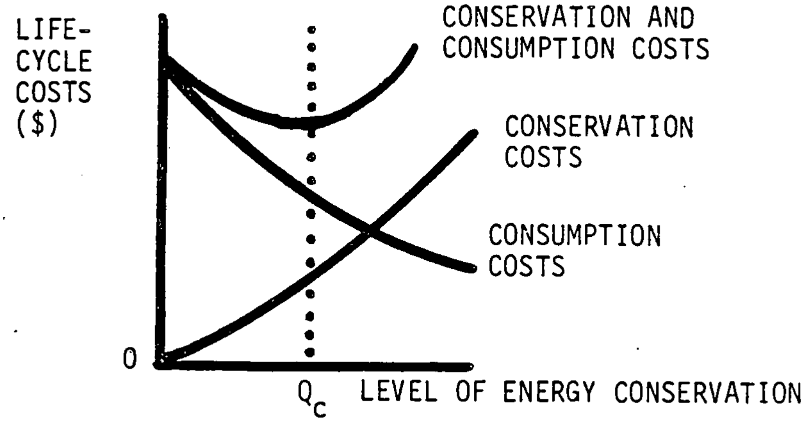


FIG. 1b LEVEL OF ENERGY CONSERVATION THAT MAXIMIZES NET BENEFITS

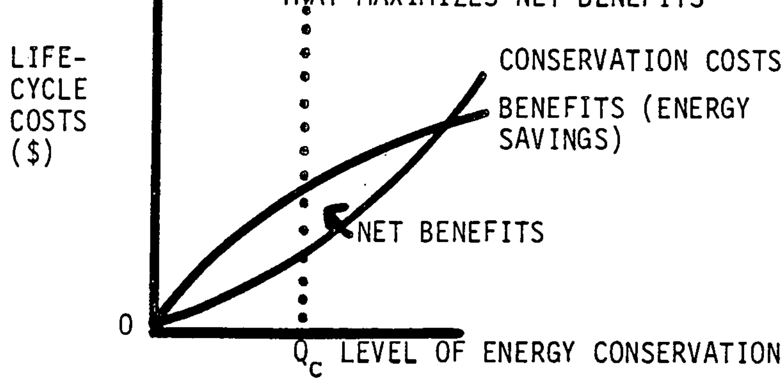


FIG. 1c LEVEL OF ENERGY CONSERVATION THAT MAXIMIZES NET BENEFITS

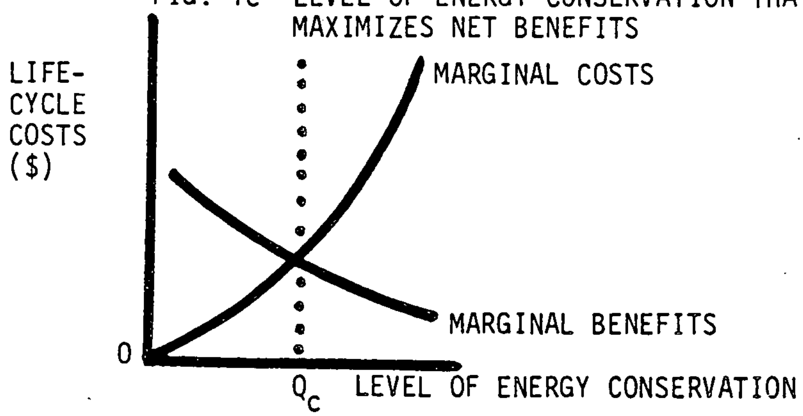
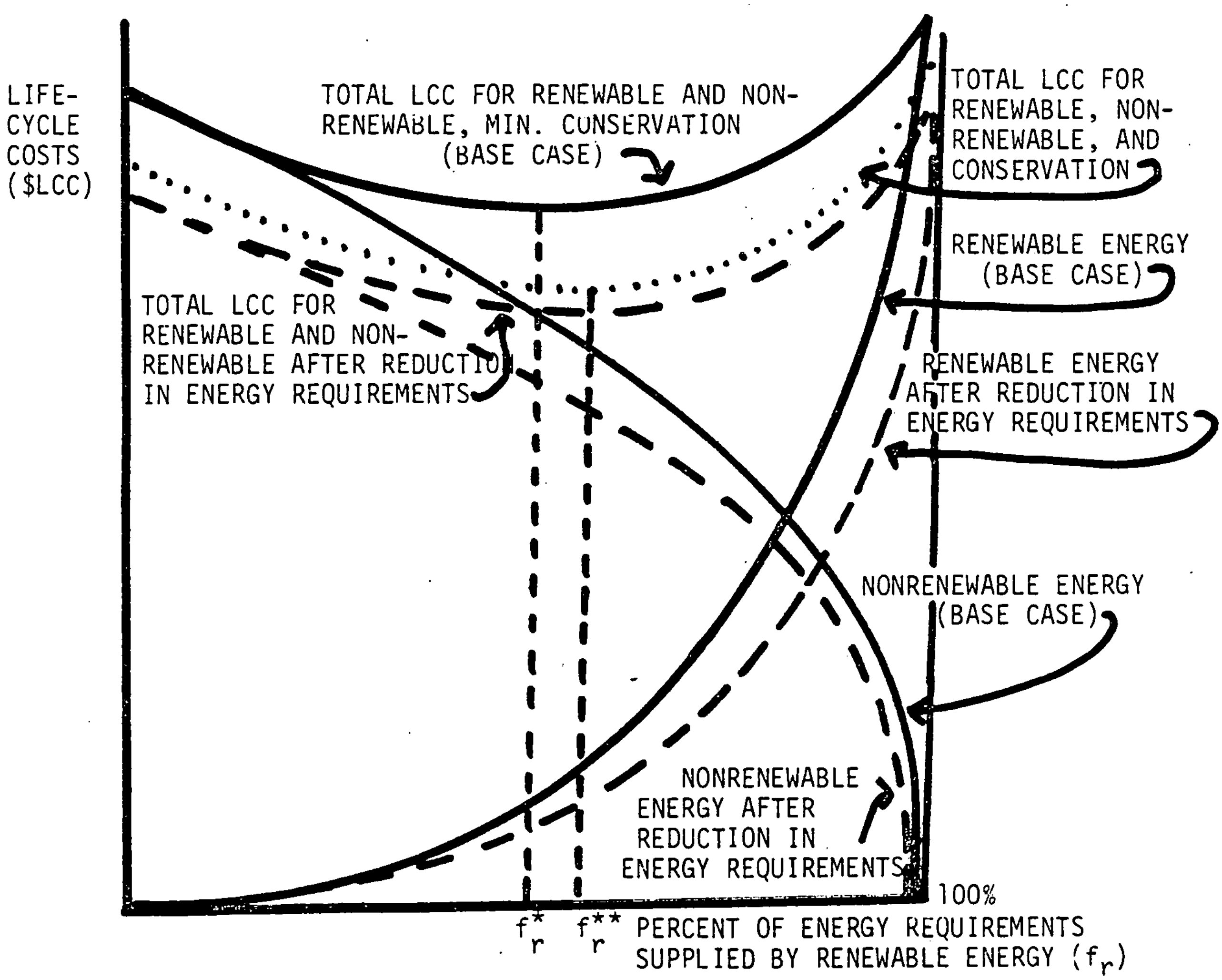


FIGURE 2

FINDING THE OPTIMAL COMBINATION OF RENEWABLE ENERGY, NONRENEWABLE ENERGY, AND ENERGY CONSERVATION



The lower two dashed curves show a new tradeoff between renewable and nonrenewable energy based on a higher level of energy conservation. More conservation means less of both renewable and nonrenewable energy. The top dashed curve shows the total combined cost of the two energy sources excluding the cost of the additional conservation.

The dotted curve shows the new total combined cost with the cost of the additional conservation added in. In this illustration, the dotted curve--though higher than the dashed curve--is lower than the original (solid) total cost curve. This means that the higher level of energy conservation is more cost effective than the initial lower level of conservation. The figure also shows that it is more cost effective to meet the energy requirement that remains after conservation with a combination of renewable and nonrenewable energy rather than completely with nonrenewable energy. Furthermore, the figure shows that with the increased level of conservation, it pays to provide a slightly higher percentage of the energy requirements with renewable energy. (This is indicated on the horizontal axis by the shift from f_r* to f_r**).

With this brief description of the economist's concern for economic efficiency in energy conservation investments, let us now identify some related concerns. To increase the comprehensiveness of their accounting of the costs and benefits of energy conservation, economists use a life-cycle costing approach. This means that they measure the net effect over time of reducing fuel costs by purchasing, installing, maintaining, operating, repairing, and replacing fuel-conserving features. They employ the technique of discounting to place all values on a common time basis. Hence, the life-cycle costing/discounted cash flow analysis method has become closely identified with economic evaluations of energy conservation.

Beyond the study of what kinds and levels of energy conservation are economically efficient, economists are concerned with how to achieve the economically efficient use of energy conservation. In this regard, they deal with a variety of economic topics and tools, such as pricing policies to encourage conservation and/or to change the scheduling of use of conventional energy sources; subsidies to purchasers of renewable energy and conservation to account for the fact that societal benefits from reductions in the use of fossil fuels may not be fully reflected in the direct dollar savings realized by the private investor; and financing and marketing arrangements which may affect the rate at which renewable energy and conservation are adopted.

In addition, economists sometimes address the concerns of special interest groups to develop ways of influencing the distribution of the gains from energy conservation. They may, for example, identify strategies for enhancing the profits of a manufacturer of energy conserving products.

These are but a few of the topics that concern economists in the area of energy conservation. Perhaps, however, this brief overview will serve to introduce the next subject: the specific kinds of problems that economics can address.

C. WHAT PROBLEMS IN ENERGY CONSERVATION CAN ECONOMICS HELP SOLVE?

Economics can help solve important problems in energy conservation faced by each of the parties identified earlier--designers, engineers, builders, manufacturers, public utilities, policy makers, and consumers. Table #1 lists some questions that, while far from exhaustive, are representative of those each of these parties might ask.

A designer will often find it necessary to justify to a client on economic grounds an energy conservation feature of a new building design. For example, he or she may wish to provide an estimate of the net life-cycle savings of a Trombe wall, a massive wall directly behind a large glazed solar collector area which serves as heat storage. To evaluate the cost effectiveness, it is necessary to estimate the energy gains and losses from the Trombe wall and the life-cycle dollar value of those gains and losses. It is also necessary to estimate the construction costs, any maintenance and replacement costs, and the expected life of the system. These values can then be combined in a life-cycle cost model and compared against the alternative wall. The client can then be advised as to the Trombe wall's cost effectiveness.

TABLE 1 QUESTIONS ABOUT ENERGY CONSERVATION

Party	Representative Questions
Designer	Will a Trombe wall be cost effective for a nursing home in Boston?
Engineer	What is the optimal size for a solar heating system for a school in Phoenix?
Builder	Which energy conservation features should receive priority in a given housing development?
Manufacturer	How should a new energy conservation product be priced?
Public Utility	How can rate schedules best be designed to reduce peak loads?
Policy Maker	What government policies will most cost effectively promote the rapid utilization of solar energy?
Consumer	How much insulation should I add to my attic?

An engineer may be called upon to design and size a solar energy system. The most cost-effective system will depend both on the comparative technical performance and on the life-cycle costs of the various options. As the design parameters are changed--with the focus usually on changing the size of collector area--an iterative calculation approach can be used to determine the system for which life-cycle costs of the total energy components of the building are minimized.[1] The size of the system should be increased as long as each additional increment provides the necessary return on the dollar.

A builder is faced with a host of energy conserving features that may be profitable for a given housing market, but he or she is typically constrained by a limited budget. To maximize profits, it is important to give priority to those features which will most enhance the salability and selling price of the houses. An economic ranking of the alternatives is useful to determine their priority. This can usually best be accomplished by computing for each alternative either a ratio of savings to costs (i.e., a benefit/cost or savings- to- investment ratio) or the internal rate of return, and then ranking and giving priority to the alternatives in descending order to their ratios or their rates of return.

Unfortunately, the problem may not be solved so simply. A critical question that complicates the answer to the builder's question is the comparative market response to the conservation alternatives. It is possible that some energy conservation features, though saving more than they cost over the life-cycle, may not add sufficiently to the selling price of the house to be worthwhile to the builder; furthermore, some features that save more energy at lower cost than others may be less desirable from the standpoint of the builder because their market demand in a given housing market is less.

The possible divergence between the cost effectiveness of an energy conservation feature based on its costs and savings versus its cost effectiveness to the builder taking into account market demand may reflect imperfections in the housing market due, for example, to lack of information on the part of the consumer. It may also reflect considerations such as aesthetics that are not fully reflected in the dollar estimates of costs and savings associated with the alternatives. In any case, this possible divergence is of vital concern to builders and requires them to consider market information to avoid unprofitable decisions. This situation, if serious, may warrant some form of government intervention, such as providing consumer information, to try to reduce the market imperfections.

Market information is also often required by the manufacturer of energy conservation. Measures of the responsiveness of market demand to a change in the price of a good or service (i.e., the price elasticity of demand) can inform the manufacturer whether to expect revenues to rise, fall, or remain about the same if prices are raised.

In a series of articles in the Public Utilities Fortnightly, Alfred Kahn, now the President's chief inflation fighter, and formerly Chairman of the Department of Economics at Cornell University and a public utility regulator, explored the use of economics in addressing questions of critical importance to public utilities.[(2)] In the second of his three articles he discusses how "marginal principles" of economic theory can be used to design rate structures that will reduce peak energy demands. Despite problems in its application,[(3)] marginal cost pricing--or some variation thereof--is becoming increasingly recognized and utilized for altering the use patterns of energy. Putting it simply, this is done by pricing consumption at higher rates when the costs of supply are high.

A related issue of interest to economists is the effect of rate schedules on the cost effectiveness of solar energy. For example, marginal cost pricing of electricity may cause the recharging of a storage component by off-peak electricity to be cheaper than by an active solar energy system.

Government decision makers charged with promoting the commercialization of solar energy use economic models to assess alternative policy options and to predict the market penetration of solar energy under different scenarios of government policy and other input assumptions.[(4)] In order to understand how best to intervene in the market and in order to determine the net benefits of that intervention, it is essential to have an idea of how the market will perform with and without different types and levels of government intervention, as well as an estimate of the social value of the predicted change in market performance.

Another area in which government decision makers are using economic analysis to guide policy actions is in the area of standards development for energy conservation in buildings. Economic analysis is being used to determine the economically efficient levels of energy conservation in different types of buildings using different energy sources and located in different climatic regions.(5)

Economics can also address problems of direct concern to consumers. For example, analysis has been made of the economically efficient levels of insulation for houses with different energy sources, located in different climates. The results have been put into a booklet that assists the homeowner in making economically sound investments in energy conservation.(6)

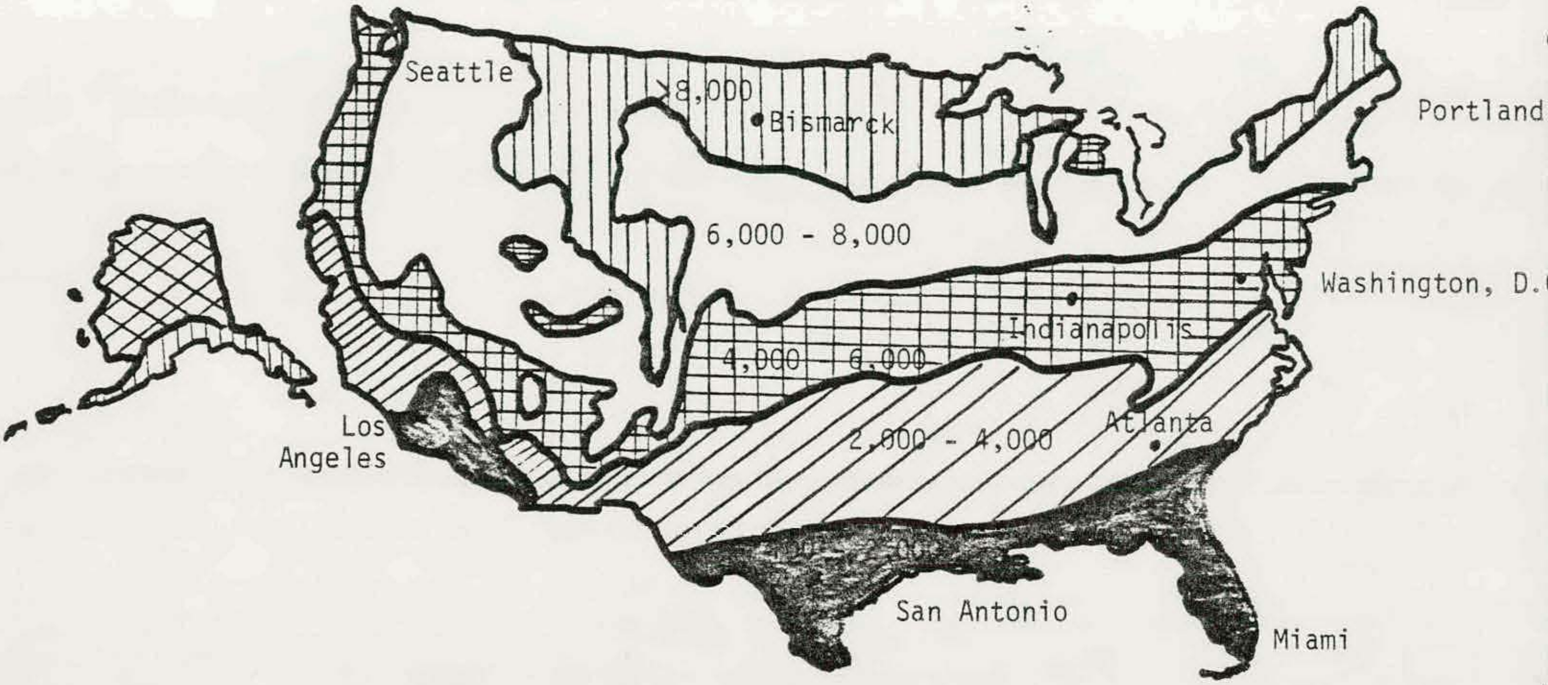
D. AN EXAMPLE

Now that we have had an overview of the role of economics in energy conservation, let us see briefly in a case example how the results of economic analysis can answer related questions of mutual concern to the various members of the building community who are interested in energy conservation. The example is taken from an interdisciplinary study of windows recently completed by researchers at the National Bureau of Standards.(7) It analyzes the energy and life-cycle cost effects of alternative window choices in a room of a "representative" house in nine cities located in different climate regions of the United States.(8)

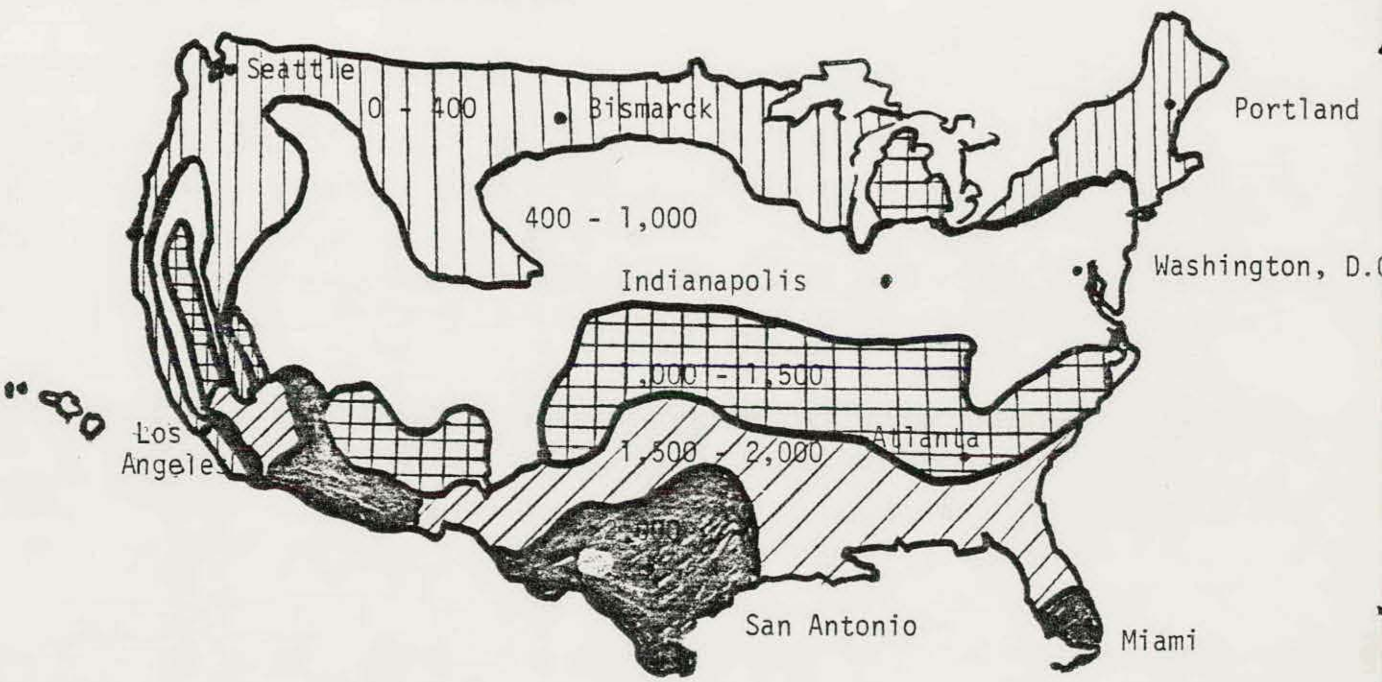
The maps in Figure 3 show the city locations and the heating and cooling zones for which the windows were examined. Table 2 lists the window choices that were examined and some of the key assumptions. In addition to considering alternative window sizes, orientations and glazings, the study investigated the effects of using venetian blinds and

Figure 3 LOCATIONS STUDIED FOR WINDOW SYSTEMS

3a Normal Heating Degree Days (Base $65^{o}F$)[a]



3b Summer Cooling Hours Over $80^{o}F$[b]



[a] This version of heating degree day distribution across the U.S. is simplified for the purpose of illustration. For the more detailed map from which it was derived, see Heating and Cooling Day Data, Environmental Information Summaries C-14, September 1974, p. 7.

[b] This map, taken from Madeleine Jacobs and Steve Petersen's "Making the Most of Your Energy Dollars in Home Heating and Cooling," NBS Consumer Information Series 8, 1975, is approximate only. For a more extensive listing of cooling hour data, see Insulation Manual-Homes/Apartments, NAHB Res. Found. Inc., 1971, pp. 23-35.

[redacted]

TABLE 2 WINDOW ALTERNATIVES EXAMINED FOR EACH REGION

FEATURE	ALTERNATIVES EXAMINED
Window type	Wood, Double Hung and Weatherstripped
Window Accessories	Venetian Blinds and Thermal Shutters
Building Application	18' x 15' x 8' Family Room/Kitchen of Single-Family Brick Rambler Brick and Block Construction
Window Sizes	0, 12, 18, 30, 60 ft.^{2}
Orientation	S, SW/SE, E/W, NW/NE, N
Glazing Type	Single, Double, Triple
Mode of Window Use	(1) Bare, Not Used for Daylighting, (2) Managed, Used for Daylighting
Internal Energy Loads	Lights: 0.65 watts/ft^2 Equipment: 0.52 watts/ft^2 Air Leakage: 0.5 Air Changes/hr. People: 0.5 people at 260 Btu/hr.
System Operation	Boiler Efficiency: 0.65 Cooling COP: 2.0 Thermostat Adjustment: 72° to 62° F Winter Nights; 78° to 84° F Summer Nights
Economic Assumptions	Gas Heating at $0.30 per therm, Electric Cooling and Lighting at $0.03 per KWh Energy Price Escalation Rates of 0%, 12% Discount Rate of 8%
Economic Performance Measures	$ Life Cycle Cost of Each Combination of Alternatives Least-Cost Window Size, Orientation, Glazing, Mode of Use, and Overall System

thermal shutters as accessories to the window, and of taking advantage of any available daylight from the window to turn off electric lights in the room. The evaluations were performed with a life-cycle costing model.[9]

Table 3 presents a summary of some of the evaluation results.[10] Columns 3 through 7 give the results for one of the cases examined in the study: the case when venetian blinds and thermal shutters are not used (I will refer to the window without these accessories as "unmanaged") and available daylighting is not substituted for electric lighting. Columns 8 through 11 give the results when the accessories are used (i.e., the window is "managed) and daylighting is used to lower the costs of electric lighting.

Column 7 gives the estimated life-cycle dollar amounts by which the costs of the room would be raised (a positive dollar amount) or lowered (a negative dollar amount) by having a window system of the size designated in Column 4, as opposed to having a solid wall with no window. These results assume that the window is unmanaged and not used for daylighting. Column 11 gives similar dollar estimates, assuming that the window is managed and used for daylighting.[11]

We can see from Column 3 that for all locations it is cheaper under the assumed conditions--that is, not managing the window and failing to save energy costs by using daylight--to have a windowless room than to have even small windows. If windows are to be used, Column 4 shows that the smallest window size examined in the study, 12 ft^2, is the least-cost size.

Column 8, on the other hand, shows that, under the assumptions of this study, the windows are cost effective when managed and used for daylighting because their savings in energy outweigh their higher costs for purchase, installation, maintenance and repair. The accessories--the venetian blinds and thermal shutters--reduce the undesirable heat gains and losses from the windows to low levels, while the savings in electricity for lighting more than offset the costs of purchase, installation, maintenance and repair.

Table 3 Regional Summary of Cost-Effective Alternatives for Residential Windows[a]

City (Heating & Cooling Zones)[b]	Fuel Price Escalation Rate (%)	Unmanaged, Not Used for Daylighting: Least-Cost Window Size	Least-Cost Window Size Greater Than 0 ($ft.^2$)	Least-Cost Orientation	Least-Cost Glazing for Least-Cost Window Greater Than 0	$ LCC[c]	Managed, Used for Daylight: Least-Cost Window Size	Least-Cost Orientation	Least-Cost Glazing for Least-Cost Window Greater Than 0	$ LCC[c]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Washington,	0	0	12	South	Single	89	12	South	Single	-89
D.C. (3,4)	12	0	12	South	Double	130	18	South	Single	-773
Miami,	0	0	12	North	Single	115	12	North	Single	-149
Florida (1,1)	12	0	12	North	Double	271	18	North	Single	-1000
San Antonio,	0	0	12	North	Single	88	12	North	Single	-145
Texas (1,1)	12	0	12	North	Single[d]	185	18	North	Single	-986
Los Angeles,	0	0	12	North	Single	59	12	North	Single	-125
California (1/2, 5)	12	0	12	North	Single	35	30	North	Single	-1051
Atlanta,	0	0	12	South	Single	60	12	South	Single	-147
Georgia (2,3)	12	0	12	South	Single	80	18	South	Single	-972
Seattle,	0	0	12	South	Single	97	12	South	Single	-39
Washington (3,5)	12	0	12	South	Double	146	18	South	Double	-600
Indianapolis,	0	0	12	South	Single	104	12	South	Single	-62
Indiana (3,4)	12	0	12	South	Double	159	18	South	Double	-660
Portland,	0	0	12	South	Double	103	12	South	Single	-29
Maine (4,5)	0	0	12	South	Triple	136	18	South	Triple	-489
Bismark,	0	0	12	South	Double/Triple	108	12	South	Single	-23
North Dakota (5,5)	12	0	12	South	Triple	147	18	South	Triple	-489

[a]Taken from Rosalie T. Ruegg and Robert E. Chapman, A Regional Assessment of Selected Window Systems, National Bureau of Standards Report (In preparation), 1979.

[b]Numbers in parenthesis refer to the heating and cooling zones, respectively, as given by the heating and cooling zone map in Figure 3.

[c]The difference in dollar costs with windows as compared with the costs without windows over a 25 year life cycle. Positive figures indicate the amount that windows add to life-cycle costs; negative figures, the amount that windows save.

[d]There is only a slight difference between the costs of single and double glazing when energy escalation is at 12%.

Columns 5 and 9 show the orientation of the windows which results in the lowest cost or greatest savings. It may be seen that neither management and daylighting nor the rate of fuel price escalation change the least-cost orientation. A southerly orientation is recommended for regions with significant heating loads, and a northerly orientation for regions with little or no heating loads.

Columns 6 and 9 indicate whether single, double or triple glazing is least costly for windows of the size given in Columns 4 and 8, respectively. It may be seen that the use of window accessories influences the preferred glazing type. Single glazing is more often recommended for the managed window than the unmanaged window because the thermal shutters provide a partial substitute for multi-glazing. The preferred type is also influenced by the rate of escalation in fuel prices; the higher the escalation, the more favorable multi-glazing becomes.

Note that these conclusions are critically dependent on the assumptions and might be different for a different set of conditions. Testing the sensitivity of results to assumptions and to estimated values of costs and benefits is a step that is often helpful to interpreting the results of economic evaluations such as this one. In this case, for example, the results are tested for sensitivity to the rate of fuel price escalation.

Time does not permit a thorough assessment of the findings of this study; rather, let us consider in general how the results reported in Table 3 can assist the various parties in their energy conservation decisions.

The results would suggest to designers, builders, or homeowners that they should give close attention to the window designs they select, as well as to the sizing, placement, accessorizing, and use of those windows. The results would suggest to policy makers that they should use caution in making policy recommendations and setting standards that call for across-the-board reductions in window areas in buildings for the sake of energy conservation. The results would suggest to manufacturers of windows that increasing attention is being focused on windows as energy losers or savers and that the market for energy conserving windows and accessories is likely to be a growing one.

To summarize, this paper has attempted to give some background and perspective of the role that economics can play in energy conservation. It has discussed the economist's perspective of energy conservation, has listed different kinds of questions that economics can address, and has given an example of economics applied to the evaluation of the energy and cost performance of alternative window systems.

FOOTNOTES

1. For a discussion of mathematical programming approaches to sizing a solar energy system, see Arthur E. McGarity, Jeanne W. Powell, Richard L. Francis, The Mathematical Programming Approach to Solar System Design, National Bureau of Standards Report (In Press), 1977.
2. Alfred E. Kahn, "Application of Economics to Utility Rate Structures," Public Utilities Fortnightly, Vol. 101, No. 2, January 19, 1978, pp. 13-17.
3. Randall K. Anderson, "The Problems of Marginal Cost Pricing and its Progeny," Public Utilities Fortnightly, Vol. 102, No. 8, October 12, 1978, pp. 17-19.
4. For a description of current solar policy options, see U.S. Department of Energy, Analysis of Policy Options for Accelerating Commercialization of Solar Heating and Cooling Systems, HCP/M2534-02, February, 1978. For a summary of leading market penetration models for solar energy, see The Market Penetration of Solar Energy: A Model Review Workshop Summary, Solar Energy Research Institute, SERI-16, January, 1978.
5. Stephen R. Petersen, The Role of Economic Analysis in the Development of Energy Standards for New Buildings, National Bureau of Standards, NBSIR 78-1471, July, 1978.
6. Madeleine Jacobs and Stephen R. Petersen, Making the Most of Your Energy Dollars in Home Heating and Cooling, National Bureau of Standards Consumer Guide, June, 1975.
7. For an overview of the interdisciplinary study, see Belinda L. Collins, et. al., A New Look at Windows, National Bureau of Standards, NBSIR 77-1388, January, 1978.
8. Rosalie T. Ruegg and Robert E. Chapman, A Regional Economic Assessment of Selected Window Systems, National Bureau of Standards Report (In preparation), 1979. (In addition to the residential case studies, this report describes the results of nine similar case studies for an office

module in a "representative" office building.)

9. The model is described in detail in Rosalie T. Ruegg and Robert E. Chapman, An Economic Evaluation of Windows in Buildings: Methodology, National Bureau of Standards, Building Science Series (In Press), February, 1979.

10. The reader is cautioned that although these findings are based on our best available thermal and cost data at this time, they are tentative. Revisions may result from extension and field validation of the thermal model used to estimate the effects of windows on energy use.

11. The estimates of life-cycle costs include the additional costs of purchasing and installing the windows over and above the costs of a solid wall, the costs of venetian blinds and thermal shutters, the costs of maintenance, repair, and replacement of the windows and the accessories, and the costs of energy for heating, cooling, and lighting the room (excluding any benefits from using the windows for natural ventilation). Benefits and costs associated with views, psychological effects, safety and other factors are not included.

Dup

THE DOE-2 BUILDING ENERGY ANALYSIS COMPUTER PROGRAM

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ABSTRACT

Concern with energy conservation requirements has resulted in a growing awareness throughout the architectural/engineering community of the need for an easy-to-use, fast-running, completely documented, public-domain computer program for the energy-use analysis of buildings. DOE-2 has been developed to meet these needs. The program emphasizes ease of input, efficiency of computation, flexibility of operation, and usefulness of output. A key factor in meeting these requirements has been achieved by the development of a free-format Building Design Language (BDL) that greatly facilitates the user's task in defining the building; its heating, ventilating, and air conditioning (HVAC) systems; and its operation. This paper describes the DOE-2 program.

A. INTRODUCTION

Approximately one-third of the total energy consumed in the United States is used to operate buildings. Only by the efficient use of energy in each building will we reduce our energy consumption at local and, eventually, national levels. Saving energy in buildings will require new public policies, new building codes, and innovations in the design of buildings and communities. It will also require new design procedures and tools for engineers and architects, correct operation of building energy systems, and careful attention to the quality of materials and construction.

Until recently, building designers lacked the necessary tools for the comprehensive calculation of dynamic heating and cooling loads, the simulation of heating and cooling distribution systems, the modeling of equipment supplying the required energy, and the calculation of the life-cycle costs of owning and operating building energy systems. Calculation of the response of building envelopes and systems to time-dependent variations of heat and moisture resulting from the weather outside and human activity inside is practical only with the aid of a computer. Earlier energy analysis computer programs have had limitations: they have been expensive to run, difficult to use, or limited in scope. Furthermore, differences in algorithms and assumptions may cause different programs to give widely differing results.

Therefore, there was a need for an easy-to-use, fast-running, well-documented, widely available computer program for the analysis of energy use in buildings. In response to this need, three national laboratories collaborated to develop a new computer program for design, analysis, research, and code compliance. Lawrence Berkeley Laboratory (LBL), as the lead laboratory, collaborated with the Los Alamos Scientific Laboratory (LASL) to develop the DOE-2 program. DOE-2 is an improved version of the former DOE-1 program, which itself is an improved, updated version of the former Cal-ERDA program. The Argonne National Laboratory and Consultants Computation Bureau were collaborators with LBL and LASL on Cal-ERDA and DOE-1.

The DOE-2 LOADS routines are based on American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) algorithms.[1,2] The primary and secondary systems simulation routines are based on algorithms developed by Consultants Computation Bureau in the early 1970's.

B. DESCRIPTION

DOE-2 can simulate hour-by-hour performance of a building for each of the 8760 hours in a year. Input is facilitated by a newly developed computer language, called the Building Design Language (BDL), whereby the user instructs the computer in familiar English terminology. DOE-2 also provides a means of performing the complicated analysis of energy consumption without the necessity of preparing input to the program that is correct in every minor detail. A set of default values (numbers used for the value of a variable if the user does not assign one) is included to reduce the amount of input that must be supplied to run the program.

Figure 1 shows a brief organizational configuration of the DOE-2 computer program. A detailed description of an earlier version of DOE-2 is found in Ref. 3.

DOE-2 has four simulation subprograms. These are executed in sequence, with the output of one becoming the input to the next. The function of each subprogram is summarized below.

1. LOADS Subprogram

The LOADS subprogram calculates the hourly heating and cooling loads, using primarily the algorithms described in Ref. 1. DOE-2 provides a reorganization and reprogramming of many of these algorithms to increase execution speed.

In the LOADS subprogram, the heat gains and losses through walls, roofs, floors, windows, and doors are calculated separately. Heat transfer by conduction and radiation through the building skin is computed, using response factors, considering the effects of the thermal mass; placement of insulation; sun angle; cloud cover; and building location, orientation, and architectural features. Infiltration loads can be calculated on the basis of the difference between the inside and outside conditions and on an assumed leak rate (crack method), or by an air-change method.

Internal use of energy for lighting and equipment is also computed according to schedules assigned by the user for each piece of equipment that affects the energy balance of each space. The latent and sensible heat given off by the building occupants are calculated as an hour-by-hour function of the occupancy of the building.

All the LOADS computations are performed on the basis of a fixed temperature for each space as specified by the user. Because the LOADS program calculates thermal loads on the basis of hourly weather data using

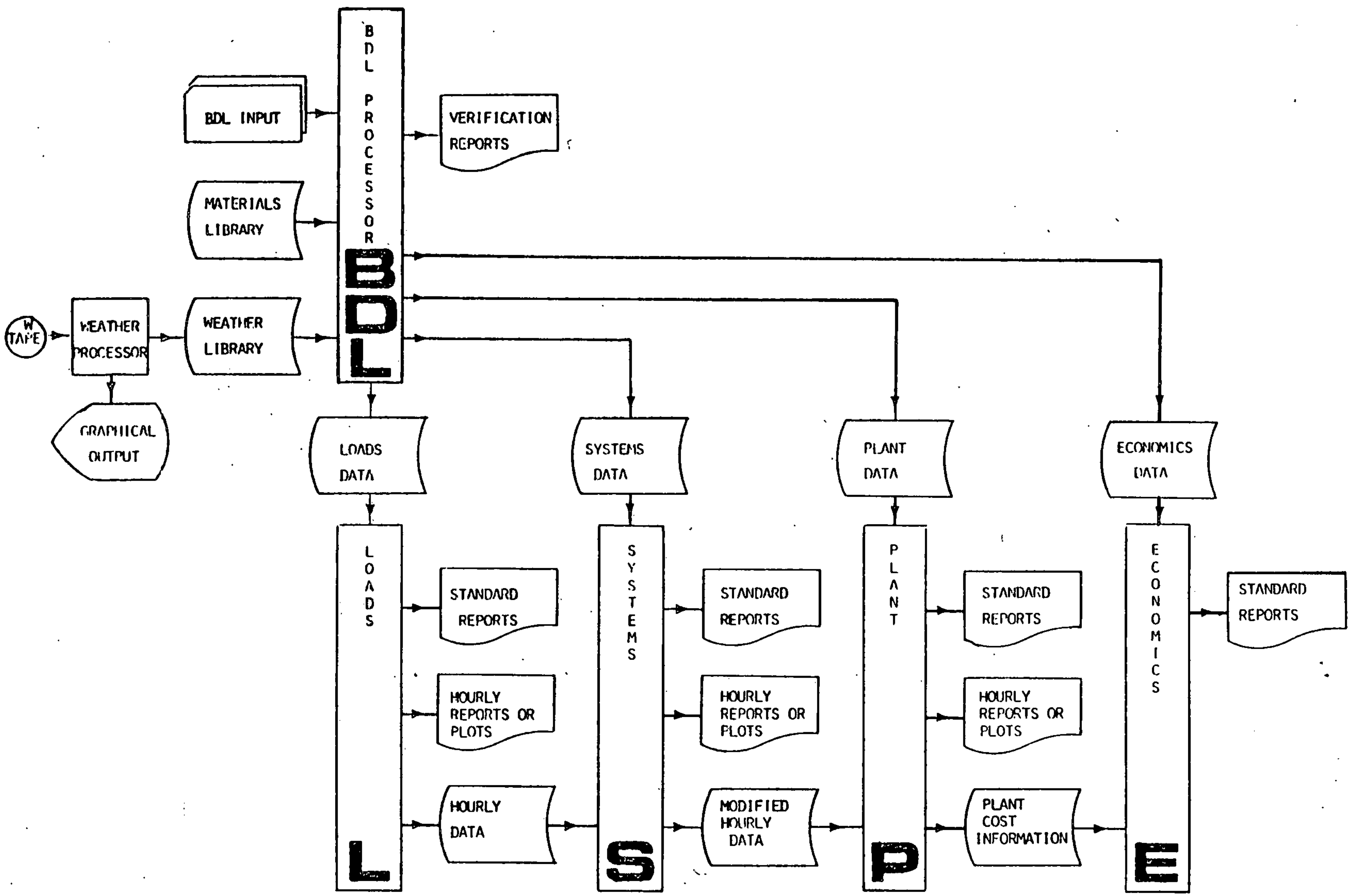

Fig. 1. DOE-2 Computer Program Configuration

artificial (fixed) space temperatures, the output may have little bearing on the actual thermal requirements of a building. It is, instead, a baseline profile of the thermal performance of a space, given a fixed internal temperature. The SYSTEMS program then modifies the output of the LOADS program, to produce actual thermal loads based on an hourly variable internal temperature.

2. SYSTEMS Subprogram

The SYSTEMS subprogram contains algorithms for simulating performance of the secondary HVAC equipment used to control the temperature and humidity of each zone within the building. Many of the equations used to develop the SYSTEMS simulation procedure are given in Ref. 2. These algorithms have been organized and coded to allow selection of one of 16 preprogrammed space-conditioning systems. The SYSTEMS subprogram is used by choosing one of these preprogrammed systems and providing the necessary input data for the simulation calculations. New subroutines, which can be developed and entered by the user, are necessary for study of a system that has not been preprogrammed.

The SYSTEMS subprogram uses the output information from the LOADS program and a list of user-defined system characteristics (e.g., air-flow rates, thermostat settings, schedules of equipment operation, or temperature setback schedules) to calculate the hour-by-hour energy requirements of the secondary HVAC system. The SYSTEMS subprogram calculates thermal loads based on variable temperature conditions for each zone.

3. PLANT Subprogram

The PLANT subprogram contains the equations necessary to calculate the performance of the primary energy conversion equipment. The operation of each plant component (e.g., boiler, absorption chiller, compression chiller, cooling tower, hot water storage tank, and solar heater) is modeled on the basis of operating conditions and part-load performance characteristics. The user selects the type of plant equipment to be modeled, the size of each unit, the number of units, and the number of units simultaneously available. Values for equipment lifetime and maintenance may also be entered if preprogrammed values for these variables are not used. The sequence of equipment operation may be specified as a step function of the load. The user may schedule equipment operation by time (hourly or seasonally) or by peak load schedules. The PLANT subprogram uses hourly results from the LOADS and SYSTEMS subprograms and the user's instructions to calculate the electrical and thermal energy consumption of the building. The DOE-2 PLANT subprogram also contains subroutines for computing the life-cycle costs of plant equipment.

4. ECONOMICS Subprogram

The ECONOMICS subprogram may be used to compute the life-cycle costs of various building components and to generate investment statistics for economic comparison of alternative projects. The methodology used is similar to that recommended by the Department of Energy for evaluation of proposed energy conservation projects.(4)

In addition to these simulation subprograms, DOE-2 contains various report-generating routines that print hourly values of selected variables over specified intervals. There is also a Weather Data Processor that allows extraction, editing, and display of hourly weather data from weather tapes.

Finally, DOE-2 contains two computerized libraries that can be accessed by the user from the program using BDL. The first, a materials library, contains thermal data for different materials commonly used in walls, roofs, and floors. The second, a weather library, contains hourly weather data for 75 locations in the United States. (With the DOE-2 Weather Data Processor, the user can easily add other locations to this library.)

C. BUILDING DESIGN LANGUAGE

The four subprograms called LOADS, SYSTEMS, PLANT, and ECONOMICS, are indicated by L, S, P, and E, respectively, in Fig. 1. The input to these programs is provided by using BDL. The information given by the user through BDL is processed by the BDL Processor Program and fed into the L, S, P, and

E data files in appropriate form. Thus, BDL, as a problem-oriented language, assists the user in communicating with the simulation programs.

The BDL Processor checks each BDL instruction for proper form, syntax, and content. The BDL instructions are read sequentially, and each is examined to determine whether any BDL commands or keywords have been used and if values have been assigned. The BDL Processor also checks for values that are beyond the expected range for input variables. If values are not specified, the BDL Processor assigns an assumed (default) value, which will appear in the listing of input data. The BDL Processor also collects whatever data the user desires from the various permanent libraries (e.g., data from the Materials Library). Response factors, three series of numbers that are used to determine the transient flow of heat through exterior walls and roofs as they react to randomly fluctuating climatic conditions, are also calculated by the BDL Processor for use by the LOADS and SYSTEMS subprograms. The BDL Processor also prepares the input data files for use by the LOADS, SYSTEMS, PLANT, or ECONOMICS (LSPE) subprograms.

For different types of users, there may be a variety of problem sizes and a wide spectrum of detail required. The problems may range from very detailed consideration of heat transfer through a single wall to a gross model of an entire building as a single zone. In responding to the challenge of this complexity, BDL simplifies the energy analysis of buildings without compromising the flexibility required for different levels of detail.

BDL has the following features:

- BDL uses engineering language. The input is entirely in the language of the engineers using BDL. No conventional programming experience is necessary to describe a problem or to interpret the results.
- There are no rigid input formats. Input data can be specified in any form convenient to the user. In other words, BDL is designed with the engineer, and not the keypunch operator, in mind.
- The sequence of input is flexible. The user has the freedom to specify the sequence of input best suited for each individual problem.

- The language is efficient. Because no two problems are ever expected to be exactly alike, the user can specify the input so that BDL executes it as if it were a special purpose program written for that one particular problem. The processing of small problems is not penalized by BDL's ability to process large problems.
- Parametrics are easily accomplished. A parametric study can be performed in a single run simply by adding a few cards to the input deck.

D. APPLICATIONS

DOE-2 can be used to study a large range of energy-conserving possibilities, including

(1) Effect of the thickness, type, and relative position of insulation in exterior walls and roofs;

(2) Effect of occupant, lighting, and equipment schedules;

(3) Evaluation of intentionally undersigned primary HVAC systems by calculating the room temperature and humidity deviations from a design set point;

(4) Effect of intermittent operation such as the shutdown of HVAC systems during the nighttime or on weekends;

(5) Effect of reduction in outside air requirements and use of outside air for cooling;

(6) Effective use of internal and external shading;

(7) Off-peak heating or cooling of buildings to shave peak heating or cooling demands; and

(8) Use of solar energy for heating and cooling.

DOE-2 can be used profitably in many stages of decision-making, including

(1) Predesign selection of the basic elements of the building, primary and secondary HVAC systems, and energy source;

(2) Evaluation, during the design stage, of specific design concepts and modifications;
(3) Evaluation, during construction, of contractor proposals for deviations from the construction plans and specifications;
(4) Analysis of existing buildings for cost-effective retrofits; and
(5) Analysis of electric load management techniques.

E. TESTING AND VERIFICATION

The algorithms used in DOE-2 are being systematically tested by comparing program results with detailed hand calculations. In addition, a project is under way to verify DOE-2 against measured energy-use data from actual buildings.[5]

F. DOCUMENTATION

The DOE-2 Users Guide[6] is an instructional introduction to the program, while the DOE-2 Sample Run Book[7] contains detailed sample program runs for a variety of building types. A DOE-2 BDL Summary,[8] which contains a summary of all BDL commands and keywords, has also been prepared. These three documents were prepared by LBL. The DOE-2 Reference Manual[9] describes BDL in detail, and the DOE-2 Program Manual[10] describes the algorithms used in the programs and contains flow charts of the subroutines. Both of these manuals were prepared by LASL.

All of the above documents will be available in mid-April 1979 from the National Technical Information Service (NTIS), US Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

G. ACKNOWLEDGMENT

DOE-2 was supported by the US Department of Energy, Office of the Assistant Secretary for Conservation and Solar Applications, Division of Buildings and Community Systems.

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ECONOMIC ANALYSIS:
A DESIGN TOOL

By Stephen P. Bucalo

Economics plays a major role in developing energy efficient systems. It is a tremendous challenge to overcome a technical problem with limited resources; economics is the foundation for solving these kinds of technical problems as cost-effectively as possible.

The nation's ability to adapt to conditions in the energy field is continuously being tested. Our society, which is accustomed to exponential growth in energy consumption, has difficulty understanding the finite nature of fossil fuel resources. While opinion differs widely in regard to the magnitude of our "energy crisis," recent statistical data cannot be disputed. From 1947 to 1975, the U.S. consumption of petroleum increased annually by almost 4 percent, while annual petroleum production increased by less than 2 percent: in short, the increase in our nation's rate of petroleum consumption has been twice the increase in our internal production rate. Obviously, petroleum imports have had to outpace exports since 1947 to satisfy our consumption. This inequity between petroleum consumption and production has been the primary factor contributing to the United States' trade deficit in petroleum, gas, and coal since 1953. In fact, U.S. petroleum imports constituted 92 percent of the total U.S. energy imports in 1974.(1)

While it can be argued that continuing imports of large amounts of petroleum are in the country's best interest--as it allows us to conserve our own reserves--dependence upon unreliable foreign petroleum imports could jeopardize the well-being of our citizens and our national security should such imports be terminated for any reason. Moreover, the world's fossil fuel reserves are not unlimited and cannot meet the world's needs indefinitely. Our nation's ineffective use of our natural resources is evident when we consider that the most abundant energy resource in the country is coal, with a reserve up to 28 times that of petroleum.(2) In spite of this great reserve, the U.S. consumed one and a half times more petroleum than coal between 1970 and 1975, primarily in response to the environmental concerns associated with the use of coal.

Technological advances during the past decade presently permit the use of coal in an environmentally acceptable manner. The use of nuclear energy for electrical generation presently provides 12 percent of our nation's electrical needs. Known national reserves of uranium also provide the potential for a greater contribution of nuclear energy to meet our future energy requirements.

It is evident from the magnitude of the present "energy crisis" and its effect on our nation's economic well-being that specific national goals must be established to avoid undesirable consequences. The most significant goals are to:

1. Increase the use of coal and nuclear energy in an environmentally acceptable manner.
2. Decrease the consumption of energy through the increased efficiency of energy conservation techniques.
3. Develop alternate sources of energy such as solar, solid waste, tidal, wind, geothermal, and fusion with full recognition of the limitations in the quantity of energy which can be derived from these alternate sources, as well as their respective costs and research and development requirements.
4. Reduce our dependence on unreliable foreign sources of petroleum, and increase our efforts to find new reliable sources of petroleum and gas.
5. Increase storage of petroleum to offset any short-term shortages that may arise.

Any economic evaluations of the energy situation should be heavily oriented toward these objectives.

The national "energy crisis" has placed an unprecedented emphasis on economic efficiency in the design of energy systems. Traditionally, our free enterprise system has relied on the laws of supply and demand in determining the cost of any commodity, and energy is no exception.

However, the OPEC cartel has significantly altered this basic relationship as it has unilaterally controlled the supply of fuel and the related cost independent of normal laws governing supply and demand. Recent developments in Iran clearly demonstrate how our continued reliance on energy resources beyond our control can immediately affect our energy supplies.

Once known as the "dismal science," economics has become critical to the design process, a relationship that all energy-conscious decision makers must realize. For economic analysis to be effective, it must be clearly understood and implemented by energy planners across the country. The methodologies must be clear and uniform, for economic analysis can be used for more than the identification of least cost investments. Greater energy cost savings can be achieved if projects are economical in both design and cost.

The following example demonstrates economic analysis used as a design tool to maximize energy savings per invested dollar for three solar panel configurations providing about 60, 70, and 75 percent of a facility's heating. Investments in solar energy systems are regarded as energy-conserving through their substitution of renewable energy for non-renewable energy.

The most important aspect of solar analysis is the sizing of a collector area because of its impact on the system's cost and the amount of energy it can supply. This problem is complex because the cost and energy savings vary substantially as collector areas change.

The economic analysis must consider fixed costs; those associated with the solar system independent of system size; the variable costs; those associated with collector area size variations; and, finally, the energy savings associated with each collector area. With this data on hand, the optimal collector area can be determined. The optimal area will be measured by the following conditions: average annual net savings or losses, the break-even point (the price of fuel, used by conventional systems, which allows a solar system to recover its investment and operating expenses through fuel cost savings), and the degree of risk to achieve the break-even point. It is important to understand that the average annual method does not compute cost for any individual year; rather, it is an "averaging" process that better describes conditions over the long term rather than the short term. What may appear to be a long-range bargain may not be a bargain at all; obsolescence may step in and alter the entire program long before the bargain pays off. Most importantly, it may be inconsistent with long-range national objectives. Consequently, a comparison of collector areas based solely on average annual savings or losses is not adequate. As such, it is important that the analyst develop the break-even point, which considers the short-term risks associated with realizing that point of economic feasibility. The following equation demonstrates the process of optimizing collector areas:(3)

$$SAV = [(C_{f,o})(DEF)(Q_b/n)(f_{yr})(P)] - [P(C_aA_c + C_e - X) + M + I + O + T]$$

Where: Cf,o = cost of conventional fuel at year zero

DEF = discount factor times energy real growth factor

Qb = average annual combined heating and hot water load for building

n = heat plant energy conversion efficiency for conversion from purchased to delivered fuel costs

fyr = fraction of total annual load met by solar energy

P = capital recovery factor

Ca = solar energy system cost directly proportional to collector area

Ac = collector area

Ce = solar energy system costs independent of collector area

X = investment credit for solar installation

M = annual maintenance costs

I = annual insurance costs

O = annual solar system operating costs

T = net annual taxes

SFc = square feet of collector area

List of Assumptions:

1. Present Cost of No. 2 Fuel Oil = \$3.00/MBtu
2. Annual Energy Real Growth Rate = 8%
3. Annual Discount Rate = 8%
4. Economic Life = 25 Years
5. Costs of taxes and insurance are not applicable
6. Example (A) 100,000 SFc, Example (B) 85,000 SFc, Example (C) 115,000 SFc
7. Example (A) supplies 70% of the heating load
   Example (B) supplies 60% of the heating load
   Example (C) supplies 75% of the heating load

<u>Example (A)</u>:

$$\text{SAV} = [(C_{f,o})(\text{DEF})(Q_b/n)(f_{yr})(P)] - [P(C_aA_c + C_e - X) + M + I + O + T]$$

$$\text{SAV} = [(\$3.00)(25.0)(40{,}000\ \text{MBtu}/.7)(.70)(.09368)] - [(.09368)(\$35 \times 100{,}000\ \text{SFc} + \$150{,}000 - \$730{,}000) + \$30{,}000 + \$0 + \$3{,}000 + \$0]$$

$$\text{SAV} = \$281{,}040 - \$306{,}546$$

$$\text{SAV} = \langle\$25{,}506\rangle$$

Break-even point calculation:

$$\text{B.E.P.} = \frac{[P(C_aA_c + C_e - X) + M + I + O + T]}{[(\text{DEF})(Q_b/n)(f_{yr})(P)]}$$

$$B.E.P. = \frac{[(.09368)(\$35x100,000SFc+\$150,000-\$730,000)+\$30,000+\$0+\$3,000+\$0]}{[(25.0)\ (40,000\ MBtu/.7)\ (.70)\ (.09368)]}$$

$$B.E.P. = \frac{\$306,546}{\$\ 93,680}$$

B.E.P.= $3.27

Example (B):

SAV = [($3.00) (25.0) (40,000 MBtu/.7) (.60) (.09368)] - [(.09368) ($35 x 85,000 SFc + $150,000 - $520,000) + $25,000 + $0 + $2,500 + $0]

SAV = $240,891 - $271,536

SAV = <$30,645>

Break-even point calculation:

$$B.E.P. = \frac{[(.09368)(\$35x85,000SFc+\$150,000-\$520,000)+\$25,000+\$0+\$2,500+\$0]}{[(25.0)\ (40,000\ MBtu/.7)\ (.60)\ (.09368)]}$$

$$B.E.P. = \frac{\$271,536}{\$\ 80,297}$$

B.E.P.= $3.38

Example (C):

SAV = [($3.00) (25.0) (40,000 MBtu/.7) (.75) (.09368)] - [(.09368) ($35 x 115,000 SFc + $150,000 - $835,000) + $40,000 + $0 + $4,000 + $0]

SAV = $301,114 - $356,891

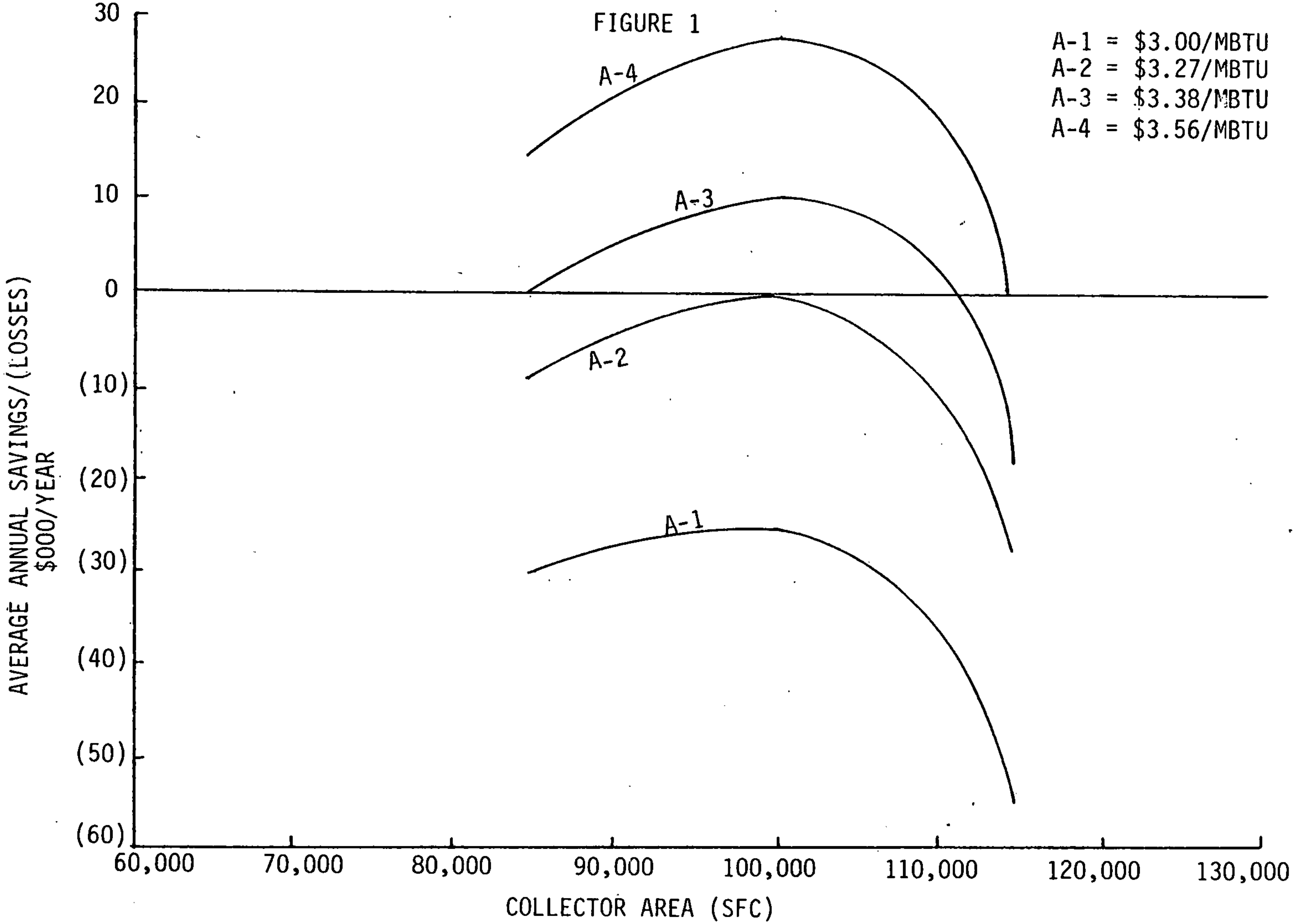
SAV = <$55,777>

$$B.E.P. = \frac{[(.09368)(\$35x115,000SFc+\$150,000-\$835,000)+\$40,000+\$0+\$4,000+\$0]}{[(25.0)\ (40,000\ MBtu/.7)\ (.75)\ (.09368)]}$$

B.E.P.= $3.56

This procedure is repeated for each collector area and results in average annual savings or losses which are plotted as a factor of collector area and fuel cost savings (as illustrated in Figure 1). This figure demonstrates that the collector area's feasibility is extremely

FIGURE 1



OPTIMAL COLLECTOR AREA

sensitive to fuel cost fluctuation. As Figure 1 indicates, the present cost of fuel oil at $3.00/MBtu (curve A-1) produces an annual loss of approximately $25,500, $30,600, and $55,800 for collector areas of 100,000, 85,000, and 115,000 square feet, respectively. As the collector area deviates from 100,000 square feet under the $3.00/MBtu scenario, the annual dollar loss rises.

As the cost of conventional fuel escalates to the break-even points, (curves A-2, A-3 and A-4), 100,000 square feet remains as the optimal collector area. Assuming that the short-term annual escalation of fuel oil approximates 12 percent, the $3.27/MBtu break-even point should be realized within one year of this analysis. Considering the time necessary to secure funds for the project, as well as its design and construction, the decision for selecting 100,000 square feet of collector area as an economically viable alternative, based on achieving the break-even point, is ~~nearly~~ risk-free. As soon as an optimal collector area has been determined, the capital investment cost, operation, and maintenance expenses and fuel savings can be combined and applied to a life cycle costing method for comparison against other alternative energy source systems.

This paper has addressed the function of economic analysis as an effective tool in optimizing the design of solar systems. If our energy systems are designed in terms of maximizing energy savings per invested dollar, then we can contribute toward a reduction in the energy trade deficit burdening our nation's economic system. However, for our nation to significantly reduce our consumption in fossil fuels, energy conservation measures must be employed in our industrial sector. This sector accounts for nearly 40 percent of the energy consumed in our country. The recently enacted National Energy Act should stimulate industrial participation through tax incentives. Combining full use of our national resources, with economically efficient energy system design, and continued governmental participation in investment incentives can make the difference between a future dependent on the demands of foreign countries, or one of sound and responsible energy management.

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ECONOMIC FEASIBILITY AND TECHNICAL
READINESS OF SOLAR
TECHNOLOGIES

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ABSTRACT

This paper is a summary of the state of commercialization of solar technologies as indicated by technical readiness and economic feasibility. It provides this data by market sector for solar thermal, Wind Energy Conversion System (WECS), Photovoltaics Systems, Ocean Thermal Conversion System (OTEC), and biomass technologies relative to the two indicators of technical readiness and economic feasibility.

A. INTRODUCTION

Two key parameters provide insight into the assessment of commercialization status of solar technologies. They are the technical readiness (does it work and at what performance level) and economic feasibility (what does it cost in the market place and what does the competition cost). These factors must be assessed on a consistent basis to provide: 1) input to the policy and funding mechanisms within the government, and 2) provide insight into those areas where improvements can be made.

The word solar technologies has come to cover a host of disciplines and ideas that are in the various stages of the commercialization process (applied research, development, field test, demonstration, and diffusion). The diffusion of these technologies is aimed at four major market areas: 1) residential/commercial; 2) industrial/agricultural process heat (I/APH); 3) Utilities; and 4) synthetic products/transportation. The technologies that are addressed here and how they relate to these market sectors is shown in Table 1.

Sector / Technology	Residential/ Commercial	I/APH	Utility	Syn. Products
Solar Thermal	1) Hot Water-Air Sys. 2) " " -Liq.Sys. 3) Space Heat-Air Sys. 4) " " -Liq. Sys.	1) Hot Water 2) Hot Air 3) Steam	Electricity (power Tower)	
WECS*	Dispersed Single Units	less than 100kw.	Electricity (Wind Farms, .1-2.5MW)	
OTEC**			Electricity (1000 MW Systems)	Ammonia
Photovoltaics	Dispersed Electic	Intermediate Elec.	1) Large Central 2) Solar Power Sat-ellite (5-10GW)	
Biomass	Woodburners (air-tight stoves)	1) SNG 2) Medium-BTU-Gas 3) Low-BTU-Gas	1) Electricity 2) SNG 3) Fuel Oil	Ethanol Methanol Ammonia

* WECS- Wind Energy Conversion System
**OTEC- Ocean Thermal Energy Conversion System

Table 1. Solar Technologies versus Market Sectors

B. TECHNICAL READINESS

For a good portion of the effort associated with solar technologies it is difficult to separate economic feasibility from technical readiness, i.e., much of the effort in R&D is directed at improvements which help the technology become economically feasible. For example, a major effort is under way on reducing the cost of photovoltaic cells to $.50 per peak watt by 1985 by improved performance and improved production processes. With that in mind, table 2 is a summary of the technical readiness assessment of solar technologies (it does not cover all aspects) and the thrust of R&D in these technologies.

The main impression to take from this assessment and other work (ref. 4,5) is that technical readiness of solar technologies is not a major obstacle to deployment and eventual diffusion of solar technologies into the market place by year 2000. Since many of these technologies will be moving into demonstration phase during the 1980's. Biomass, solar thermal systems seeming to offer the lowest technical risk.

C. ECONOMIC FEASIBILITY

It is the economic competitiveness of solar technologies that is the fundamental variable in the diffuision process. Social and environmental issues can play a secondary role (and even these can in many instances be quantified and included in the economic assessment) and can be the deciding factor when the economic position of solar costs overlaps or coincides with that of its competitors (conventional energy sources). For example, this is the case when compring electricity made from biomass versus nuclear or new coal plants.

In making the economic assissment of a solar technology there have been numerous routes taken to arrive at delivered-cost of energy or cost of service (back-of-the-envelope calculations, levelized costing, life-cycle, present value, annualized costing, first-year costing, market penetration,

Technology	Sector	Systems	Technical Readiness Assessment
Solar Thermal	Residential/ Commercial	Hot Water-Air and Liquid Systems Space Heating/Hot Water-Air and Liquid Systems Air Conditioning Systems	Numerous Systems Available (ref. 3)
	I/APH	Low Temperatur (Air, water steam)	Numerous systems available (solar ponds, flat plate collectors, evacuated tube collectors) ref.1,2.
		High Temperature (>150°C air, steam)	In the RD&D phase (line receivers, parabolic dish, power tower) ref.1,2 Demonstration: 1983 (ref.4)
	Utility	Power Tower	1) 10 MW_e Prototype Demonstration Plant (Barstow, Calif.) 2) Commercial System: Late 1980's (ref.5)
WECS	Residential/ Commercial	Single Dispersed Units (1kw-100kw)	Numerous units available. (ref.1)
	Utility	Wind Farms, Combined Cycle, Hydro-Storage	In the RD&D Phase: 1) 200kw Test in New Mexico 2) 2 MW Unit in North Carolina 3) System Studies of various strategies. Competive Electricity: Mid-1980's (ref. 5)

Table 2. Technical Readiness Assessment of Solar Technologies

Technology	Sector	Systems	Technical Readiness Assessment
OTEC	Utility	Closed Cycle System Open Cycle System	A. In the R&D Phase 1) System Studies Completed of 100-1000MW Capacity 2) Ocean Test of Components in the near-term. B. Demonstration Plant: 1985 C. First Commercial Plant: 1992 (ref. 4,5)
Photovoltaics	Residential/ Commercial	Dispersed Systems (silicon or gallium arsenide cells; flate plate or concentrator arrays; fixed position)	(1) Numerous technical demonstration projects underway (using cells with capital cost of 10^4-10^5 $/kw) ref.5 (2) Continue research in improving cell eff. from 10% to 15-20%. ref.5 (3) Research to reduce cost to $.50 per peak watt by 1985. ref.5
	Utility	Centralized Systems (earth-based systems)	(1) Same as dispersed systems. (2) Demonstration: late 1980's
		Solar Power Satellite (5-10 GW sytems)	(1) System Definition Studies (2) Environmental Impact " (3) Institutional " " (4) Demonstration: 1995 (5) Commercial Sys.:2000 Ref. 1,5

Table 2. (Continued)

Technology	Sector	Systems	Technical Readiness Assessment
Biomass	Residential/ Commercial	Space Heating (Air tight stoves, radiating or cen- ral heating units)	Fastest Growing Solar Market- (without gov. intervention) ref.1
	I/APH	Cogeneration Fuel Substituion (use medi- um-BTU-gas instead of nat- ural gas) by: gasification anerobic digestion Direct Combustion to pro- steam. Anerobic Digestion	1) off-the-shelve technology 2) Used extensively during WWII 3) Numerous suppliers of boilers and systems (developed by the forest products industry) 4) Forest Products Industry may become energy self-sfficient using own residues. 5) Other industries dependent upon assured supply of feed- stock. 6) Assured supply dependent on demonstration of energy farm by early 1980's. ref.6
	Utility	Direct Combustion (D.C.) to produce electricity	1) boiler size limited to 600,000 #steam per hour.
		Gasification Systems to pro- medium-BTU-gas, SNG,) Pyrolysis (fuel oil) Anerobic Digestion (SNG)	1) Already demonstrated by private sector on small scale. 2) Significant competition with nuclear and coal dependent upon demonstration and im- plementation of energy farm in the early 1980's.

TAble 2. (Continued).

Technology	Sector	Systems	Technical Readiness Assessment
Biomass (cont'd)	Synthetic products	Fermentation (alcohol for fuel additive and chemical feedstock) Gasfication (alcohol for fuel additive and chemical feedstock for ammonia and other products)	1) Major international and national programs in existence to make gasohol. 2) Ammonia Demonstration Plant: 1981. ref. 6.

Table 2. (Continued).

etc.). Secondly, the methods used are no better than the engineering cost estimates that go into the cost calculation. As a result much harm has come to the diffusion of solar technologies by the tendency to understate the cost of energy for solar resources and compare these cost with the cost of conventional energy which are very mature (based upon actual cost of capital, operation cost, maintenance as opposed to projected cost of a concept; have included in the capital cost the impact of meeting institutional and environmental constraints).

Not withstanding this situation an economic assessment of solar options must be made and the comparison with conventional sources will be made. The policy maker or decision maker must be aware that although projected cost show an overlap with competitive energy, it may not be so in the real world.

Tables 3,4,5,6, have graphically illustrated the projected cost of solar technologies as they stand today and in some cases in the future. The range of prices for conventional sources are shown on each table. It should be noted that many regional factors (labor cost, site specific resources, fuel cost, etc.) can influence the cost of solar energy. The band of cost shown in each table attempt to take this regional variation into account. In some cases the range of cost are also the result of uncertainty in the cost and the application of experience (cost reduction due to increased quantities of production) being incorporated.

From these data one can draw some broad conclusions relative to economic feasibility:

Residential/Commercial Sector

1) Solar Thermal Hot Water and Space Heating Systems can compete in the all electric market.
2) Biomass space heating is competitive against all conventional sources.
3) Wind/Photovoltaics (from an economic perspective) will have limited success is this sector unless "availability" of any conventional energy is the decision variable.

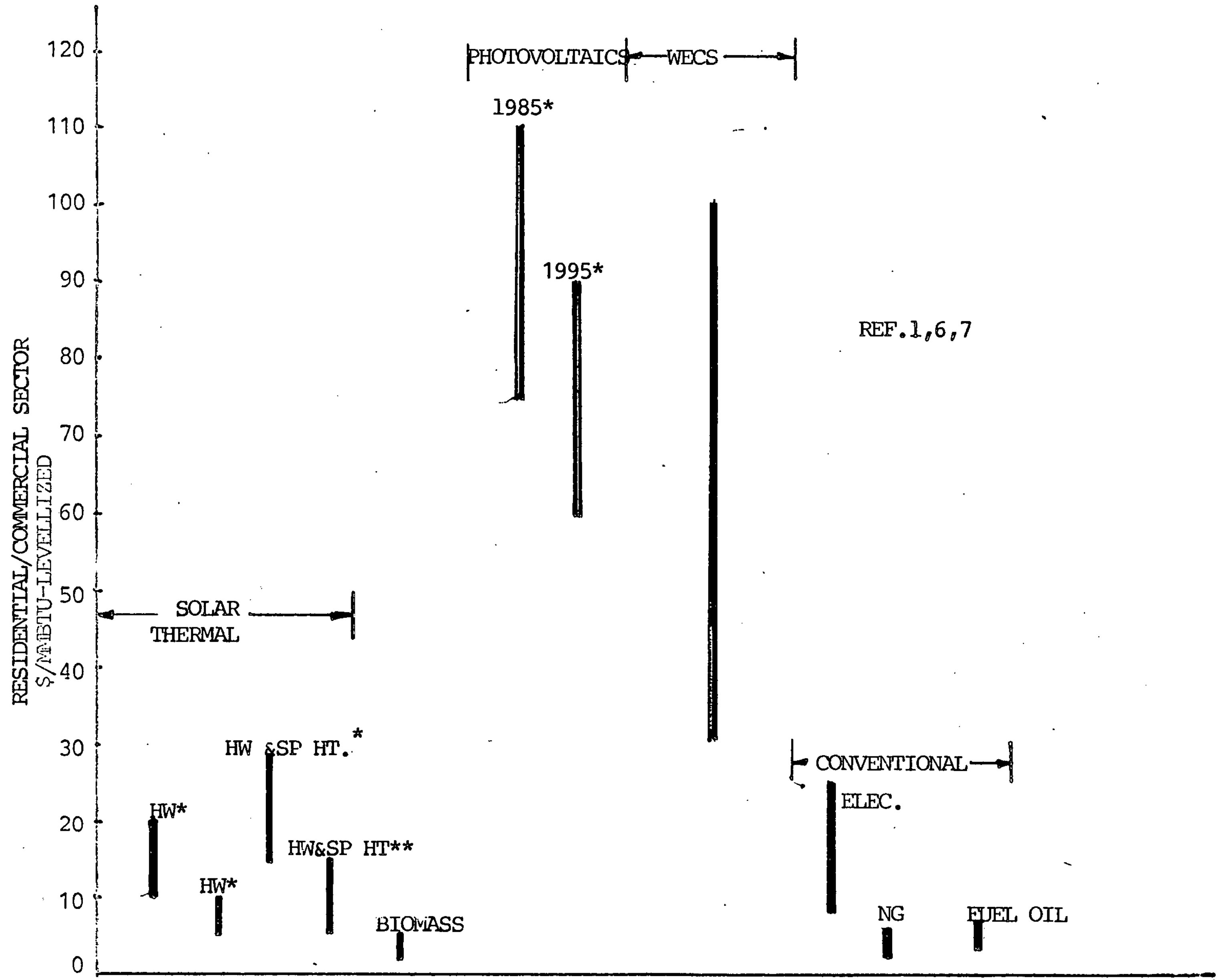

TABLE 3. Solar Technology Economic Assessment-Residential/Comm. Sector

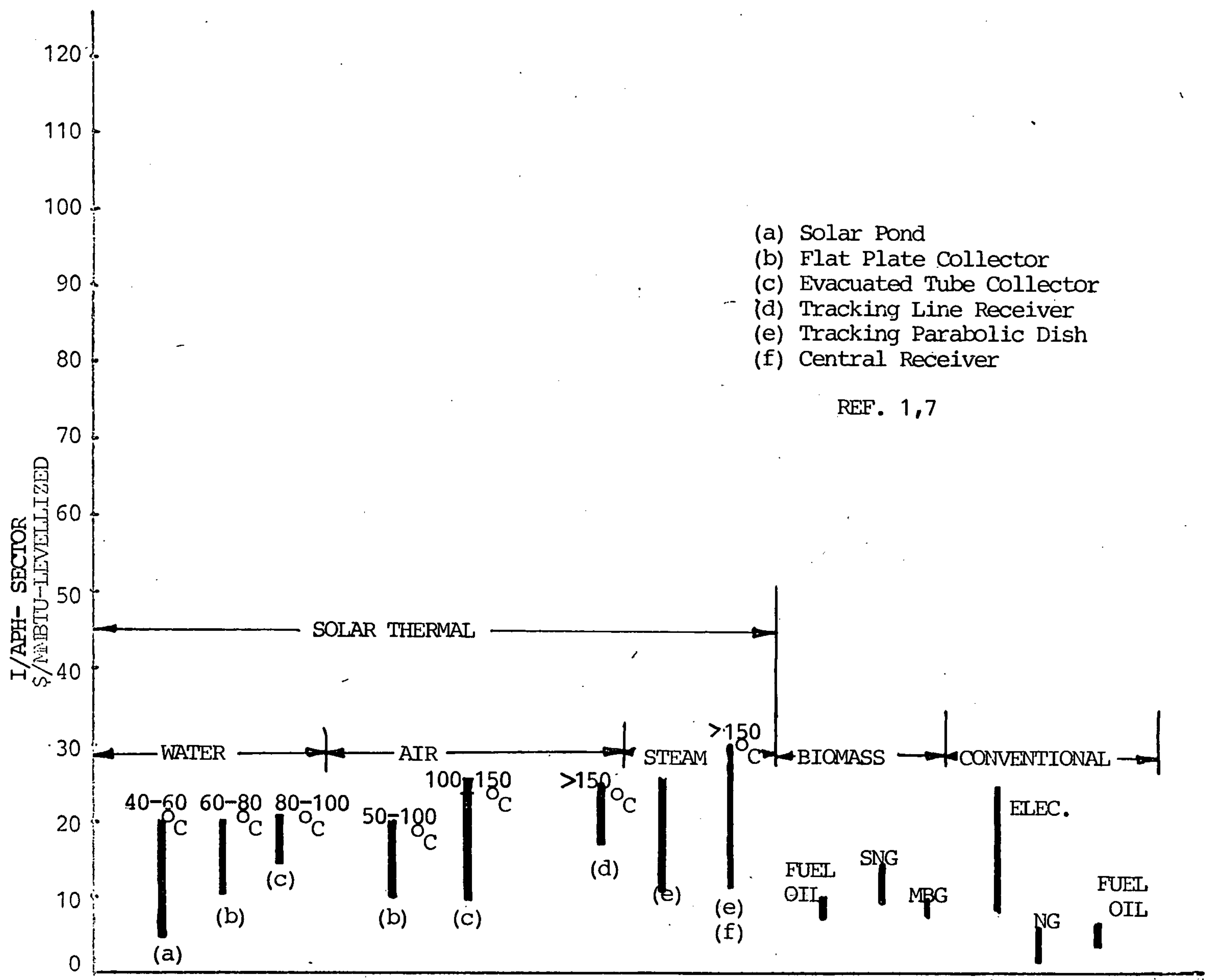

TABLE 4. Solar Technology Economic Assessment-I/APH Sector

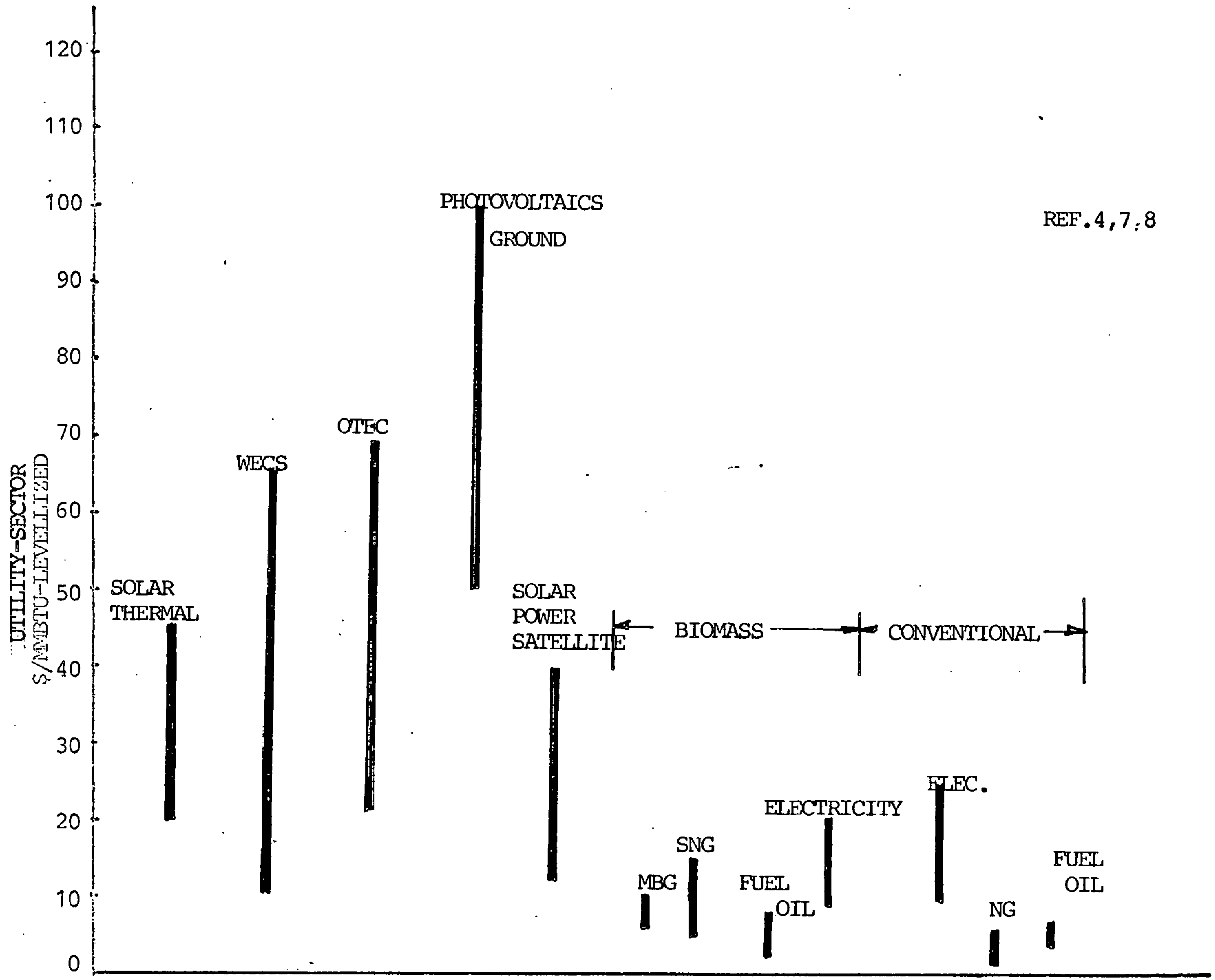

TABLE 5. Solar Technology Economic Assessment-Utility Sector

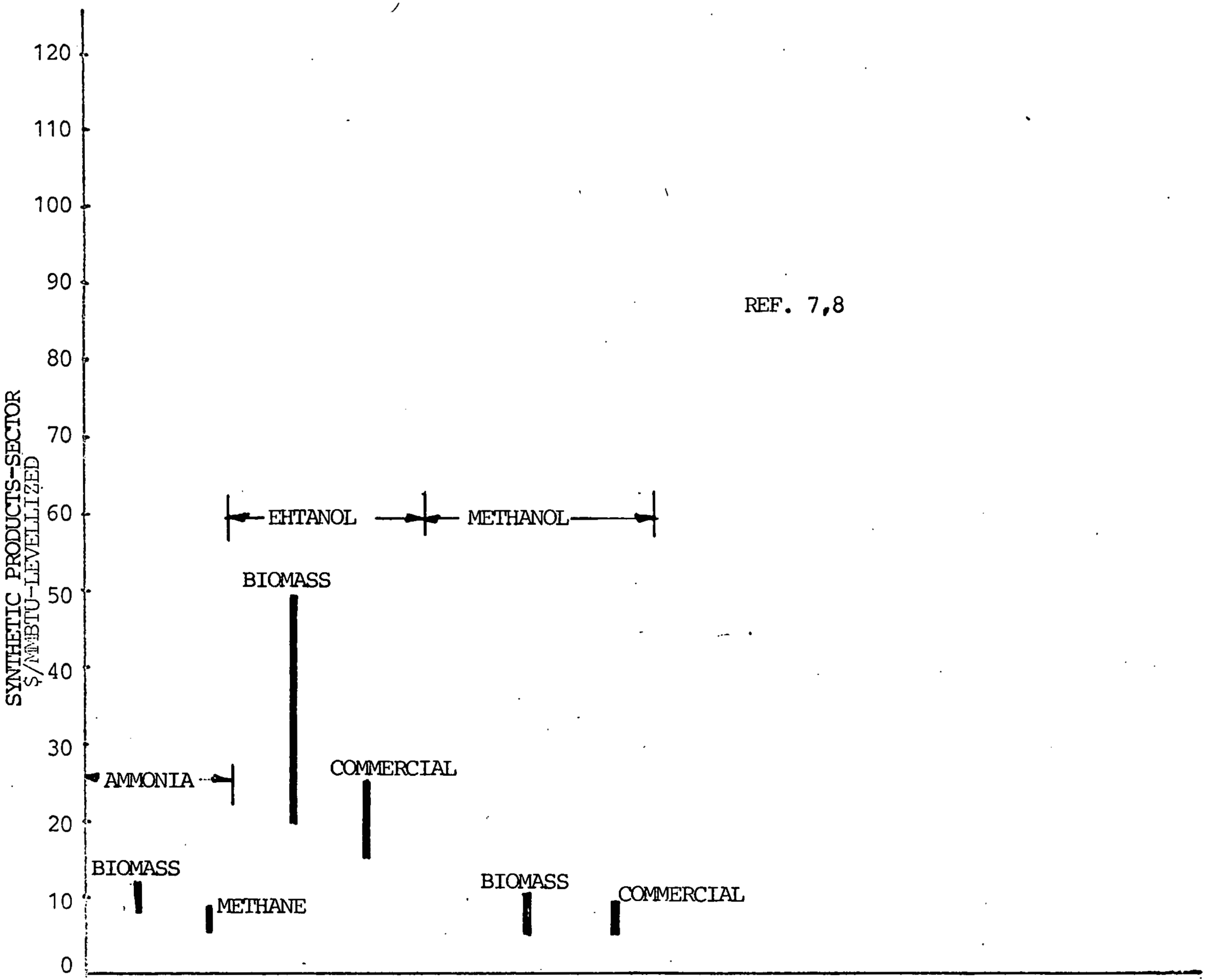

TABLE 6. Solar Technology Economic Assessment-Synthetic Products Sector

I/APH Sector

1) Represents a sizeable market for solar thermal application which is on the edge of competing economically in this sector. Availa- of conventional fuels to this sector could weigh in favor of solar application.

2) Biomass is already competing is this sector and will continue to grow into industries other than forest products as the energy farm comes on line to provide an assured supply for feedstock.

Utility Sector

1) Large uncertainty about the competiveness of Solar Thermal, WECS, OTEC, and land Photovolataics in this market.

2) Biomass and Solar Power Satellite have the best economical position in this sector.

Synthetic Fuels

1) Biomass is the only solar resource in this market and can generate economically fuels in this larket (only limited by a assured supply of feedstock).

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