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ABSTRACT

This publication acquaints the prospective marketplace with the potential and underlying logic of the Integrated Utility System (IUS) concept. This system holds promise for educational and medical institutions seeking to reduce their energy costs. The generic IUS concept is described and how it can be incorporated into existing heating and generating equipment to obtain increased system efficiency through heat recovery and recycling is discussed. Two studies are described to illustrate the positive impact of IUS, especially over the long term. The multiplicity of subsystems available to suit the individual needs of institutions is also covered in this total energy systems document. (MR)

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December 1976

The Marketability of Integrated Energy/Utility Systems

A Guide to the Dollar Savings Potential in Integrated Energy/Utility Systems;

for campuses,
medical complexes
and communities;
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industrial and power
plant owners; suppliers;
and constructors.

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DEPARTMENT OF HEALTH
EDUCATION AND WELFARE

PREFACE

As part of the cooperative effort of the Federal agencies involved in the Integrated Utility System (IUS) program, the Department of Health, Education and Welfare (DHEW) is promoting the application of the IUS concept to medical and educational complexes. Funds for the DHEW effort have been furnished by the Experimental Technology Incentives Program of the National Bureau of Standards (ETIP/NBS). The intent of the IUS applications project in DHEW is to:

- demonstrate to the medical and educational community that an IUS installation would result in considerable net savings for the institutions as well as contribute significantly to a reduction of energy consumption and to a general reduction in pollution of air, water and land.
- stimulate and encourage the marketing of IUS to the medical and educational communities by private enterprise.
- meet the philosophy of ETIP/NBS by serving as a vehicle for transfer of technology developed with Federal funds to the private sector and thereby stimulate the unassisted growth of the IUS concept through private enterprise.

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SUMMARY

The purpose of this marketing guide is to acquaint the prospective marketplace with the potential and underlying logic of the generic IUS concept. What comes to light is the fact that a sizeable number of educational and medical facilities may well be compatible with the IUS concept, and that study, and appropriate implementation of an IUS would bring about the realization of startlingly substantial annual dollar savings for the institution along with impressive energy savings.

The potential market for an IUS has been based primarily upon electrical load demands of 2,500 kW to 40,000 kW. The rationale for selecting electric power as the basis is that it is through the recovery of the energy which is normally wasted in conventional electric power generation (65 percent or greater) that the major potential for energy and dollar savings in an IUS are realized.

Having identified the market, and allowing that it is rather broadly defined, what of the IUS concept? How does it work, and what are its benefits? The IUS concept in action can possible best be likened to a cascading effect, whereby the normally wasted energy from one integral subsystem can be utilized to augment or totally operate another. It is on this principle that the advantages of an IUS are achieved.

The area of greatest positive impact following implementation of an IUS is the bottom line economic picture. As is highlighted in the resulting studies of the University of Florida and Central Michigan University, the extent of this positive impact can be substantial, especially over the long term.

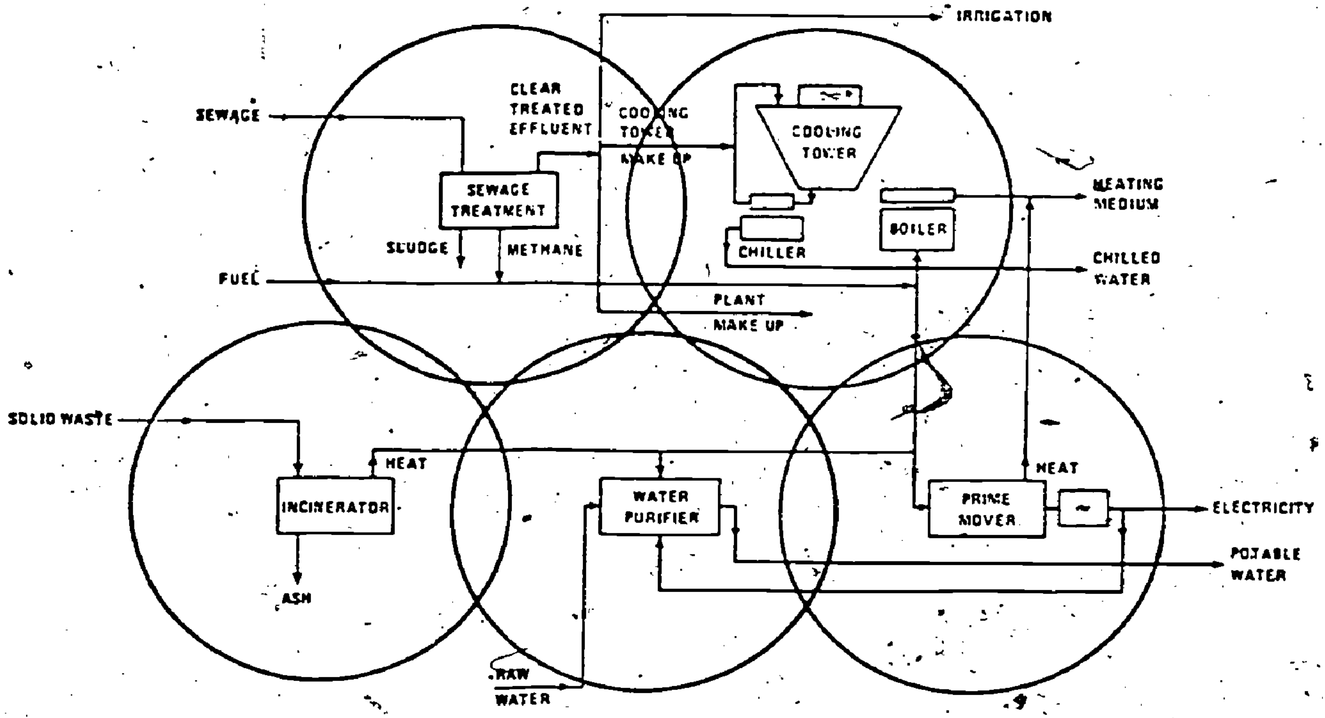
Still another advantage that continually emerges is the compatibility of the IUS concept with future planning activities. The presence of a partial IUS allows an institution the luxury of being able to incrementally incorporate various subsystems into a highly efficient operating utility system. In effect, as the operational life expectancy of a subsystem diminishes, the economic viability of integration increases since the subsystem will have to be renovated in any event. In that instance, the capital cost that need be borne by the IUS is only that due to the additional equipment required for integration and not the total investment for replacement.

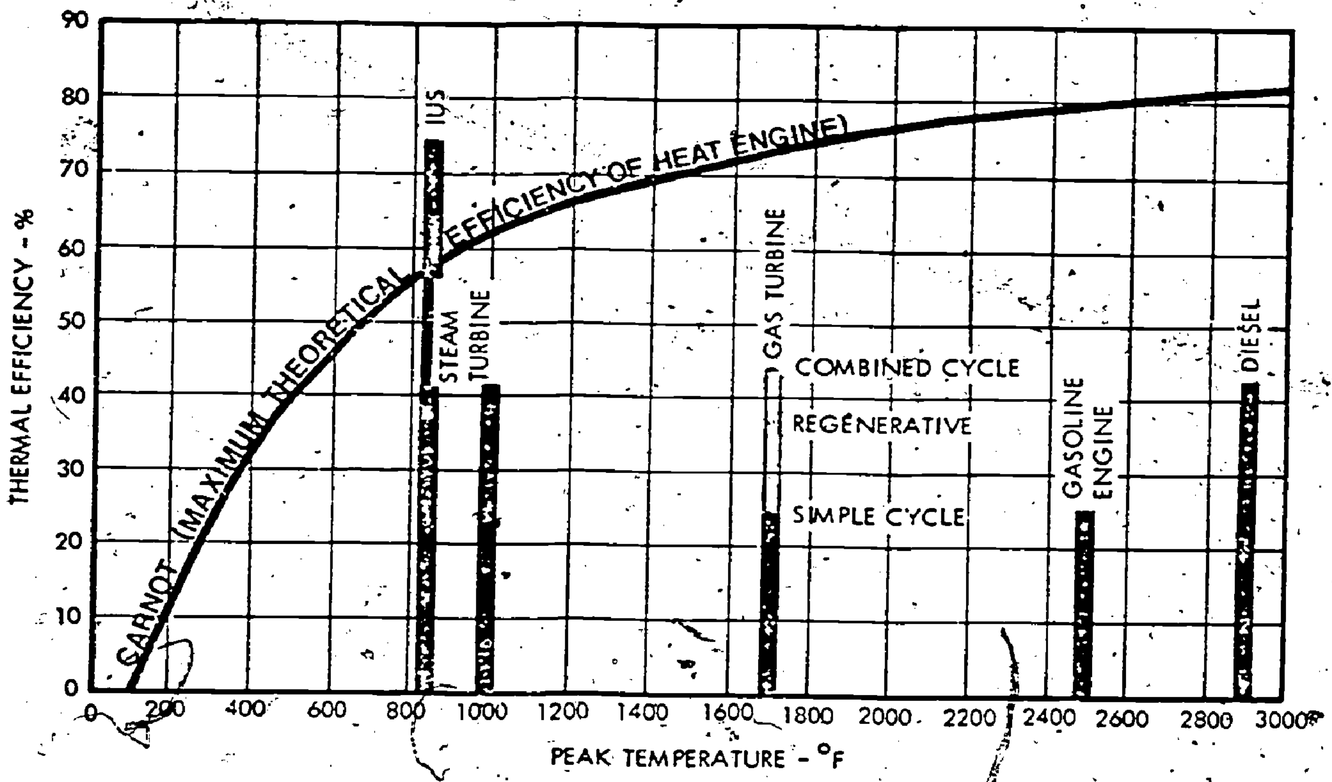
As is continually stressed throughout this document, a factor of considerable importance is the satisfactory correlation of an institution's electrical and thermal loads. The ability to utilize the waste energy of electrical generation to satisfy thermal demands is critical to the success of an IUS, and, necessarily, the benefits of this incorporation are invariably reflected both in the operational efficiency and financial success of the system. In these cases the incremental rate of return for the added IUS investment may well turn out to be very high, of the order of 25 to 100 percent or more.

I. THE INTEGRATED UTILITY SYSTEM

THE GENERIC INTEGRATED UTILITY SYSTEM

FIGURE I-1





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EFFICIENCY AS A FUNCTION OF PEAK TEMPERATURES
FIGURE I-2

THE INTEGRATED UTILITY SYSTEM

The objective of the Integrated Utility System (IUS) concept is to provide required utility services with maximum efficiency and minimal overall costs. . .and in a manner which is consistent with environmental requirements and institutional constraints. To this end, the IUS concept can become a viable option for medical and educational institutions to offset ever spiralling energy costs. By and large, current utility systems (electrical power generation, heating and cooling, water supply, sewage treatment and solid waste disposal) are typically treated as separate operating entities. The IUS concept integrates into a single system as many of these utility services as can be economically justified in order to achieve maximum utilization of heretofore wasted energy from individual subsystems. For example, the waste (or exhaust) heat from a diesel engine can be used as the energy source for an absorption type air conditioner.

Optimization is site-specific, however, this document addresses the multiplicity of subsystems available to maximize the benefits from the IUS concept. A diagrammatic representation of subsystem configurations is presented on the facing page, Figure I-1.

The essence of an operationally and financially successful IUS is on-site electrical power generation utilizing low temperature or waste heat to provide space heating and cooling requirements and hot water service. Traditionally, large commercial electric generation stations operate at approximately 35 percent efficiency; whereas, an IUS plant can attain and even exceed thermal efficiencies of 70 percent. The curve shown in Figure I-2 depicts the relative efficiencies of engines for producing power. Note that the IUS with low level heat recovery exhibits efficiencies approaching twice that of conventional systems. Due to this fact, the economic benefits can provide for investment payout in as little as 3 to 5 years. . .with continuing annual energy cost savings of 25 to 50 percent.

The success of the IUS lies in achieving a satisfactory correlation of the electrical and thermal load demands of the institution. That is, the ability to obtain the approximate 2 to 1 efficiency improvement depicted in Figure I-2 depends on being able to use effectively the recovered low level heat. Although the IUS concept encompasses up to five utility services, the maximum return is going to be achieved from on-site electric power generation integrated with space heating and cooling and hot water service requirements. This level of incorporation alone will often justify the initial capital investment.

Industry long ago recognized that on-site power generation utilizing recovered low level heat could play a major role in reducing operating costs. Consequently, many industries incorporated essentially the same concept under the name of Total Energy. Numerous shopping centers, amusement parks, and other commercial establishments soon followed suit. This took place prior to the Arab oil embargo when fuel costs were low. The savings are now even more dramatic and others are closely examining the potential benefits of Total Energy. In particular, the Department of Defense is examining the concept for application at some of their facilities.

The increasing cost and decreasing availability of fuels is serving as a catalyst to boost further interest in the IUS concept. Contributing factors are:

a) continuing escalation of electric utility rates,
b) shortage and imminent curtailment of natural gas in many regions,
c) fluctuation in fuel oil prices due to the vagaries of international oil policies, and
d) increasing environmental/energy conservation awareness.

The IUS concept, by intent, does not incorporate high risk technologies, but rather takes an innovative approach to integrating established and sound engineering practices and proven equipment to provide more efficiently the required utility services.

Consideration of an IUS could be put in the form of a question: Would a capital investment which could pay out in the neighborhood of 5 years be of interest if it could cause a 25 to 50 percent reduction in your annual energy bill consisting of fuel and purchased electricity? If so, IUS is worth considering as an option to the status quo.

THE ELEMENTS OF A SUCCESSFUL IUS

The elements to be considered and analyzed in evaluating the potential benefits of an IUS are:

- Size of institution
- Energy requirements
- Present and projected electrical rates and consumption
- Projected availability of fuels
- Capability of combusting multiple fuel forms
- Space availability
- Reliability and adequacy of public power supply
- Impact on the surrounding community
- Existing plant
- Institutional/Organizational
- Economic feasibility

As will become apparent, the optimal integration of select utility services is the key factor in deriving maximum economic benefit from an IUS. The reader should note that the cost of providing comfort heating and cooling in a university or medical complex is of the same magnitude as the electrical energy cost, and that these are the overriding major utility system costs. Thus, it is efficient integrated operation of electrical and thermal subsystems that, in all cases, provides the major economic benefits of an IUS.

In order to clarify the principle of improved efficiency through combining space heating and cooling with on-site power generation, it is desirable to review the concept of availability and reversibility in thermodynamic systems. All thermodynamic systems, e.g. high temperature combustion gases, at a given state defined by such properties as temperature, pressure, velocity and elevation, have the potential for performing a maximum quantity of work in reaching equilibrium with the environment. The maximum quantity of work is achieved by passing from the initial thermodynamic state point to a final state point through reversible processes of heat transfer and work.

For example, in a university or medical complex, thermal energy in the temperature range of 200° F to 400° F is required. Hot combustion gas at approximately 3,500° F is available to generate these thermal requirements. If reversible engines could be placed between the heat source (combustion gas) temperature and each of the low temperature heat sinks, the system operation could then approach that of a reversible system and energy requirements could be obtained in the most efficient manner. Although reversible engines exist only in theory, there are available heat engines such as steam turbines that conventionally operate with throttle temperatures of 800° F to 1,000° F and combustion turbines which operate at inlet temperatures in the 2,000° F range. By incorporating one or more of these heat engines into the system, the irreversibility could be reduced and the utilization of thermal energy improved over that of a conventional Central Energy Plant which generates steam requirements for the thermal loads with no electric power generation and maximum irreversibility.

Therefore, the system which will, in general, look most attractive in terms of highest fuel efficiency is one in which power generation is incorporated, and in which the power generation system is selected on the basis of being the optimum size to provide the thermal requirements. Any smaller power generation unit results in having to use a conventional boiler to produce the additional hot water or low quality steam required for heating and cooling. Whereas any larger unit results in a portion of the on-site electric generation system competing with the high thermal efficiency characteristic of the large power generating units operated by electric utility systems. Put differently, the plant will generally be sized so that the heating and cooling requirements are met by the waste heat from power generation. This in turn will usually mean that a significant portion, but not all of the electric power, will be generated on-site. This arrangement is sometimes called a Select Energy system.

Size of Institution

Generally speaking the IUS concept will have potential applicability in educational and medical complexes where electric demands range between 2,500 kW and 40,000 kW. In this size range, there is a high likelihood of sufficient economic return to recover the capital investment, and there is proven and available hardware to permit utilizing the lowest cost fuels available. Concurrently, the Department of Housing and Urban Development (HUD) is pursuing the potential for the Modular Integrated Utility System (MIUS) in the residential/commercial community. By comparison, the electrical energy demand for the HUD/MIUS program applications are smaller, ranging from 300 kW to 6,000 kW, which, incidentally, results in significant differences in system hardware requirements.

Energy Requirements

The data presented in Figure II-1 on the facing page was taken from a survey of 20 selected medical and educational institutions located throughout the country. Although there is considerable variation in the ratio of electrical energy to thermal energy in the systems surveyed, the range of electric power generation equipment available ideally encompasses the systems represented by this data. Typical values of the ratio of recoverable heat to electricity generated by these prime movers is superimposed on Figure II-1. Note the extreme flexibility of the steam turbine to optimally provide the thermal and electrical requirements. Further, by mixing the prime movers such as a steam turbine for baseload and a diesel for peaking (which is common), essentially any value of this important electrical to thermal ratio can be achieved.

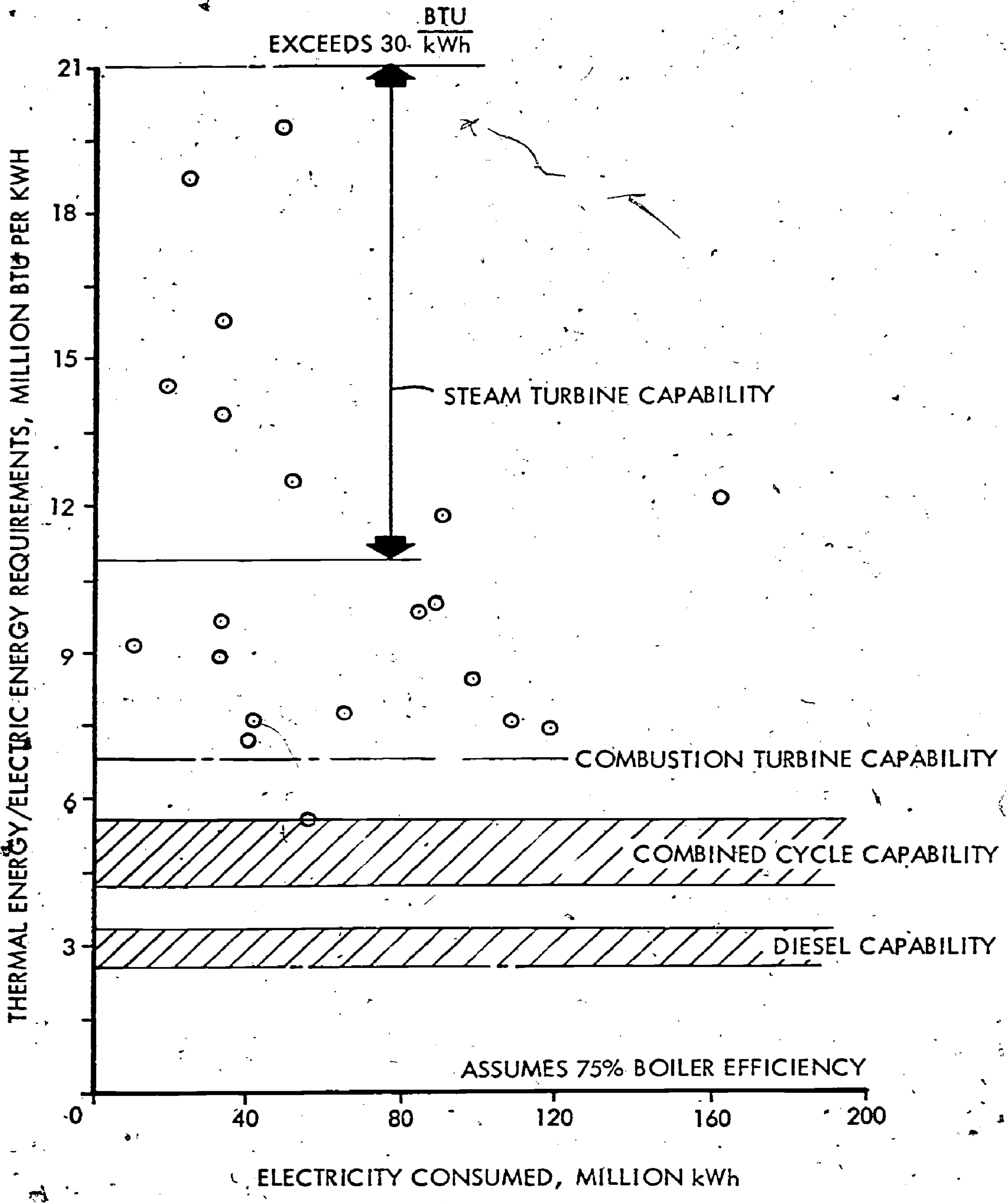


FIGURE II-1
ENERGY REQUIREMENTS OF 20 SURVEYED INSTITUTIONS

Present and Projected Electrical Rates and Consumption

Marked regional differences exist in the patterns, growth, and cost of power. The major reason is the regional differences in the cost of fuel or the type of electrical generation, e.g. many regions are supplied by existing hydro and nuclear plants and are still obtaining low cost electricity. Future power costs can be anticipated to change as the price of fuel continues to increase and capital costs escalate. Since the primary fuel, thus the cost, varies from utility to utility the projected rate of increase in the cost of electricity will be site-specific.

If central station electricity is sufficiently low in cost relative to the primary IUS fuel cost, the economic benefits of heat recovery will not be sufficient to justify an IUS with on-site power generation. Since the electricity cost data are such critical factors in the integrated utility system economics, it is necessary to closely analyze the site-specific rate structures.

Projected Availability of Fuels

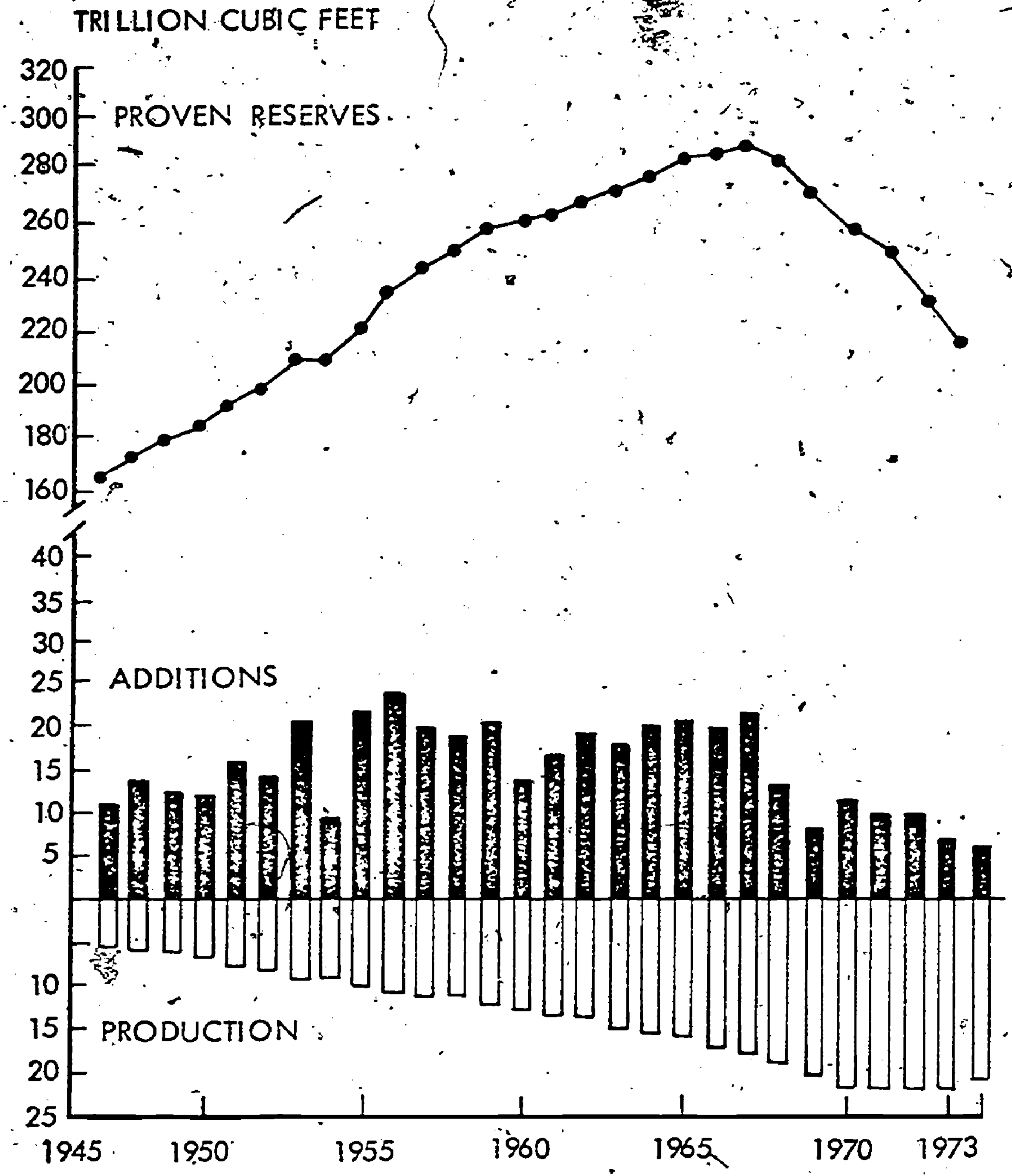
There is tremendous speculation with respect to the price and availability of a particular fuel. The following discussion is an attempt to place in perspective a number of factors that are expected to affect the future fuel picture. One natural conclusion is that if a facility is equipped to burn any of the three fuels; oil, natural gas, or coal, then there will exist the highest probability of fuel availability and at the lowest relative cost. This latter consideration should play a major role in your consideration of alternatives.

Present energy consumption in the institutions which might consider implementation of an IUS is primarily for meeting thermal requirements. Although some institutions burn coal, by far the most popular fuels are gas and oil. Both of these latter fuels are premium grade, are easy to store and handle, and have good combustion characteristics. Until recently they have been readily available and relatively inexpensive. Price increases, triggered primarily by the Arab oil embargo, have changed this picture considerably and coal, although less desirable from an operational and initial investment standpoint, is becoming more attractive from a life cycle point of view for specific geographical regions.

Natural Gas Availability: Demand for natural gas has steadily increased because of its clean burning properties, low cost, and, until recently, availability. After World War II, the availability of abundant supplies of natural gas and cross-country pipelines systems enabled the gas utility industry to expand rapidly. As shown by the production rate on Figure II-2, gas consumption grew at a 6.5 percent average annual rate in the 1950's and 1960's. Natural gas production peaked in 1973 and then declined by approximately 6 percent in 1974 for the first time in history.

U.S. NATURAL GAS RESERVES (Excluding Alaska)

FIGURE II-2



Source: American Gas Association, as printed by the Federal Energy Administration. National Energy Outlook

Reserve additions have failed to equal or exceed production for the seventh straight year. The only significant major reserve addition in recent years has been the Alaskan reserve added in 1970.

With the demand for natural gas exceeding supply, many gas companies found it necessary to deny gas service to new customers and to curtail some existing customers. The picture is not expected to improve. In fact, interruption or curtailment of supplies at most consumer levels is a very distinct possibility, and one that logically should provide the stimulus for investigation of other fuel types by the consumer.

At the time of writing this document, no state had completely implemented the Federal Power Commission Curtailment Priorities Program presented on the facing page, but most have, either through a statewide plan or by individually filed company tariffs, placed an end-use type of plan in effect. It is important to note from Figure II-8 that a large portion of the universities and hospitals which might logically implement an IUS fall in one of the lower interruptible priority categories (6 to 9) of the FPC Order 467B. Note that the higher the numerical category the greater the likelihood of curtailment. The conservation and economic benefits associated with an IUS make the timeliness of its consideration that much more appropriate, especially in light of the presence of the FPC Order. In addition, it seems inevitable that gas prices will rise, probably exceeding the price of fuel oil. The consensus is that deregulation would cause this to happen rapidly. Even regulated gas is receiving price boosts. FPC Order (Opinion No. 770) would result in the price of new natural gas being almost tripled.

Fuel Oil Availability: Until the oil imports were disrupted by the oil embargo, the United States oil consumption increased 4 to 5 percent per year. Domestic oil production peaked in 1970. The discovery of new reserves has fallen since 1966; the Prudhoe Bay field in the Alaskan North Slope being the only major exception to this trend. With consumption outstripping domestic production, the United States was dependent of foreign sources for 19 percent of its oil supply by 1959. By 1970, this dependence had grown to 26 percent, and by 1975 had reached approximately 40 percent and continues to grow.

In a recent report prepared by the Library of Congress, it was predicted that overall energy shortages will be 9 to 9.2 million barrels per day in oil equivalent in 1977; 10 to 10.6 million barrels per day in 1980; and 9 to 10 million barrels per day in 1985, assuming an energy growth rate of 2.8 - 3.1 percent yearly over the next 10 years. The Library of Congress report also noted that "any additional oil imports to the U.S. will have to come from the Eastern Hemisphere, with most of that from the Middle East and North African countries."

Exhibit I

Federal Power Commission Gas Curtailment Priorities Order No. 467-B

(1) Residential, small commercial (less than 50 Mcf on a peak day).

(2) Large commercial requirements (50 Mcf or more on a peak day), firm industrial requirements for plant protection, feedstocks and process needs, and pipeline customer storage injection requirements.

(3) All industrial requirements not specified in (2), (4), (5), (6), (7), (8), or (9).

(4) Firm industrial requirements for boiler fuel use at less than 3,000 Mcf per day, but more than 1,500 Mcf per day, where alternate fuel capabilities can meet such requirements.

(5) Firm industrial requirements for large volume (3,000 Mcf or more per day) boiler fuel use where alternate fuel capabilities can meet such requirements.

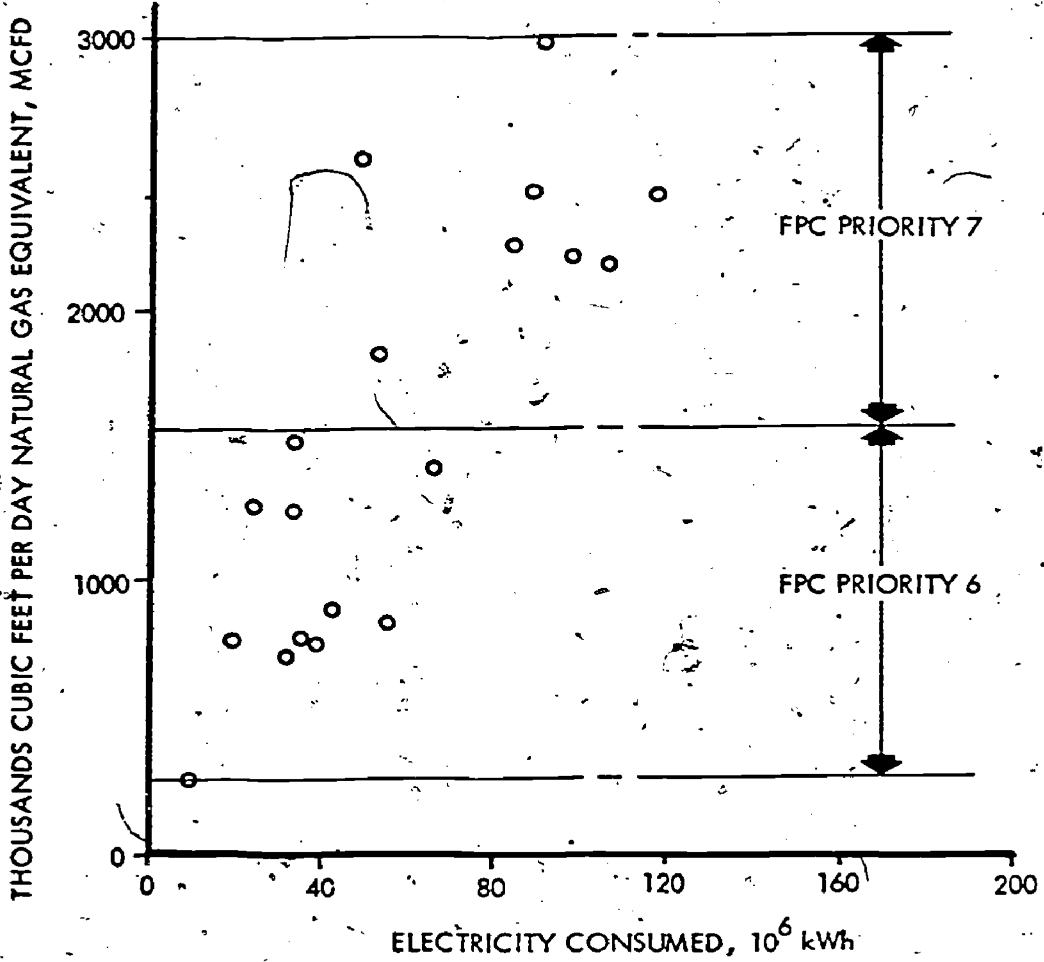
(6) Interruptible requirements of more than 300 Mcf per day, but less than 1,500 Mcf per day, where alternative fuel capabilities can meet such requirements.

(7) Interruptible requirements of intermediate volumes (from 1,500 Mcf per day through 3,000 Mcf per day), where alternate fuel capabilities can meet such requirements.

(8) Interruptible requirements of more than 3,000 Mcf per day, but less than 10,000 Mcf per day, where alternate fuel capabilities can meet such requirements.

(9) Interruptible requirements of more than 10,000 Mcf per day, where alternative fuel capabilities can meet such requirements.

FIGURE II-3 EQUIVALENT FUEL CONSUMPTION FOR TWENTY INSTALLATIONS SURVEYED



The conclusion to be drawn from these somewhat ominous predictions must be that, while oil would appear to be available as a fuel for an IUS, the supply might well be vulnerable to further disruptions as occurred with the Arab oil embargo of the not too distant past.

Coal Availability: It is widely known that our nation's coal reserves are enormous. According to a report issued by the Council on Wage and Price Stability (1976), the outlook for coal prices over the next decade is favorable with good prospects for price stability. About 83 percent of the known economically recoverable energy reserves in the nation are in the form of coal, and at current prices the mineable reserves are enormous.

While it is generally conceded that coal is not presently being produced at rates that can fill the overall energy gap, there appears to be a sufficient supply of both low and high sulfur coal to meet the needs of those installations which have the capability to burn coal. It would also appear reasonable to assume that the price of coal per Btu will continue to be lower than the price of fuel oil.

Conclusions: Although the relative availability of fuels will vary by region, it is apparent that at some juncture most institutional facilities will feel the effect of the energy crunch. In this instance the posture of your institution should be one of preparedness. Time, which is of the essence, has been lost -- so faced with the impending crunch, necessity should provide sufficient stimulus for decisive action. This decisiveness can take many forms, but if your intent is to establish some measure of independence from the fuel shortage and the rising cost of delivered energy, then the IUS concept will warrant serious consideration. On-site generation coupled with the appropriate integration of subsystems can afford greater reliability of utility services and can result in a reduction in overall energy costs, while simultaneously conserving a very valuable commodity...energy!

The Capability of Combusting Multiple Fuel Forms

As was illustrated previously, the nation is faced with the unpleasant prospect of a shortage of oil and natural gas in coming years. Further, it is anticipated that interstate natural gas prices will continue on the upward spiral that has been witnessed since 1973. Along with this potential crisis comes the difficult problem of determining who will be permitted to use these commodities. For safety's sake, assume that you will not be one of the privileged. With this in mind, explore the viability of implementing a multi-fuel combustion process. The ability to switch to alternate, more available fuels will enable your institution to "roll with the punch", hence, lessening the impact of projected shortages.

There exists a multiplicity of advantageous fuel combinations, all of which, subject to site-specific investigation, could have a dramatic effect on both stability of service and bottom line economics of operation. The latter point bears second thought, because, by intent, the multi-fuel capability affords the opportunity ofttimes to prudently substitute the combustion of the cheapest fuel available at a given time. In addition to coal, one solid fuel form that is gaining in popularity is wood residue. In certain areas, wood is available in plentiful quantities, and presently is extremely cost competitive. It is currently being burned in boilers in Alabama, Vermont, Oregon and Arkansas in quantities which encompass the size range of universities and medical facilities.

The intent here is not to promote wood, but to stress the point that, unless constrained by regulations, an institution can always be burning the least expensive fuel available at any given time. This multi-fuel capability alone could give you the ability to reduce fuel costs 10 to 20 percent.

Aside from the potential financial benefits to be derived, the most significant advantage of multi-fuel combustion capability is that it provides the highest assurance of fuel availability.

Space Availability

The type of generation system and the type of fuel under consideration can have a significant effect on land requirements. For instance, dependent of the fuel, areas have to be set aside for such incidentals as fuel storage, gas cleanup, and ash handling.

Reliability and Adequacy of Public Power Supply

A major consideration for installing on-site electric power generation in addition to cost savings is the potential lack of reliable electrical power from the conventional electric utilities. A number of authoritative sources, including sources within the electric utility industry, are predicting the strong possibility of large scale brown-outs, black-outs, and curtailments of service before the end of the 1970's in many sections of the country.

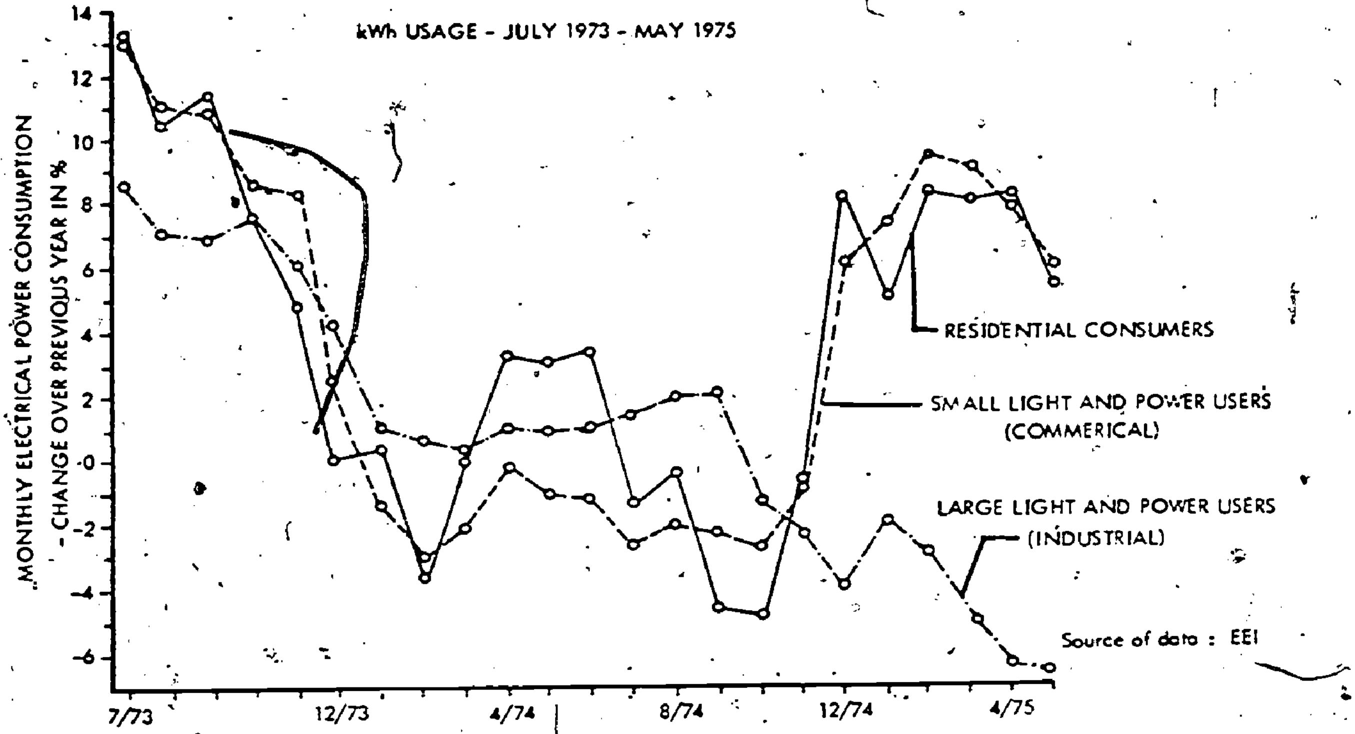
Further, according to a report by the Technical Advisory Committee for the National Reliability Council (July, 1975) entitled, Review of Overall Reliability and Adequacy of the North American Bulk Power System, certain trends are evident with regard to the lack of availability of power supply adequate to meet projected demands.

The future reliability and adequacy of electric bulk power supply depends on the timely installation of new generation and transmission facilities to meet the projected electric loads and provide sufficient reserve capacity for contingencies. The report especially emphasizes the fact that present high levels of reserve capacity in this country appear to be primarily the result of the severe decline in industrial activity.

Power consumption was considerably reduced during the period of energy awareness brought about by the Arab oil embargo in late 1973. As can be seen from Figure II-4 on the following page, demand tumbled in all sectors of electric consumption, but by 1975 the residential and commercial sectors had bounced back to near historic levels, while the industrial demand remained low. The result has been that the total kWh sales have only increased by about 2 percent this year. It has been suggested that the lagging economy is the reason for the continued reduced electrical demand by industry. When the economy improves, industrial consumption could be expected to increase if the historical correlation between power consumption and gross national product still applies. Then, instead of reserves running comfortably in excess of 20 percent, the resulting reserve picture could be as low as that shown on the facing page. Figure II-5 shows a high of 15 percent in 1976, falling steadily to a level of 7 percent in 1984. Electrical supply stability requires reserve capability in excess of 15 to 20 percent, and the lack of this level of reserve should cause administrators of institutional utility systems to be concerned about the reliability of service.

The threat of potentially unreliable electric power supply indicated by the data in Figures II-4 and II-5 is exacerbated by the possibility of future postponements and cancellations of generating plants. The magnitude of the problem is further increased by construction delays resulting from licensing problems, by nuclear controversies, environmental and site related issues, by the lack of assurance of an adequate and dependable supply of primary fuel, and by the inability of utilities to push through rate hikes they claim are necessary to provide the capital for expansion. For example, Alvin W. Vogtle, Jr., President of the Southern Company, a utility holding company, stated in SOUTH MAGAZINE last year that if his company did not get the needed construction funds, "for Georgia Power, instead of having a 20 percent reserve, we'll have only a 5 to 6 percent."

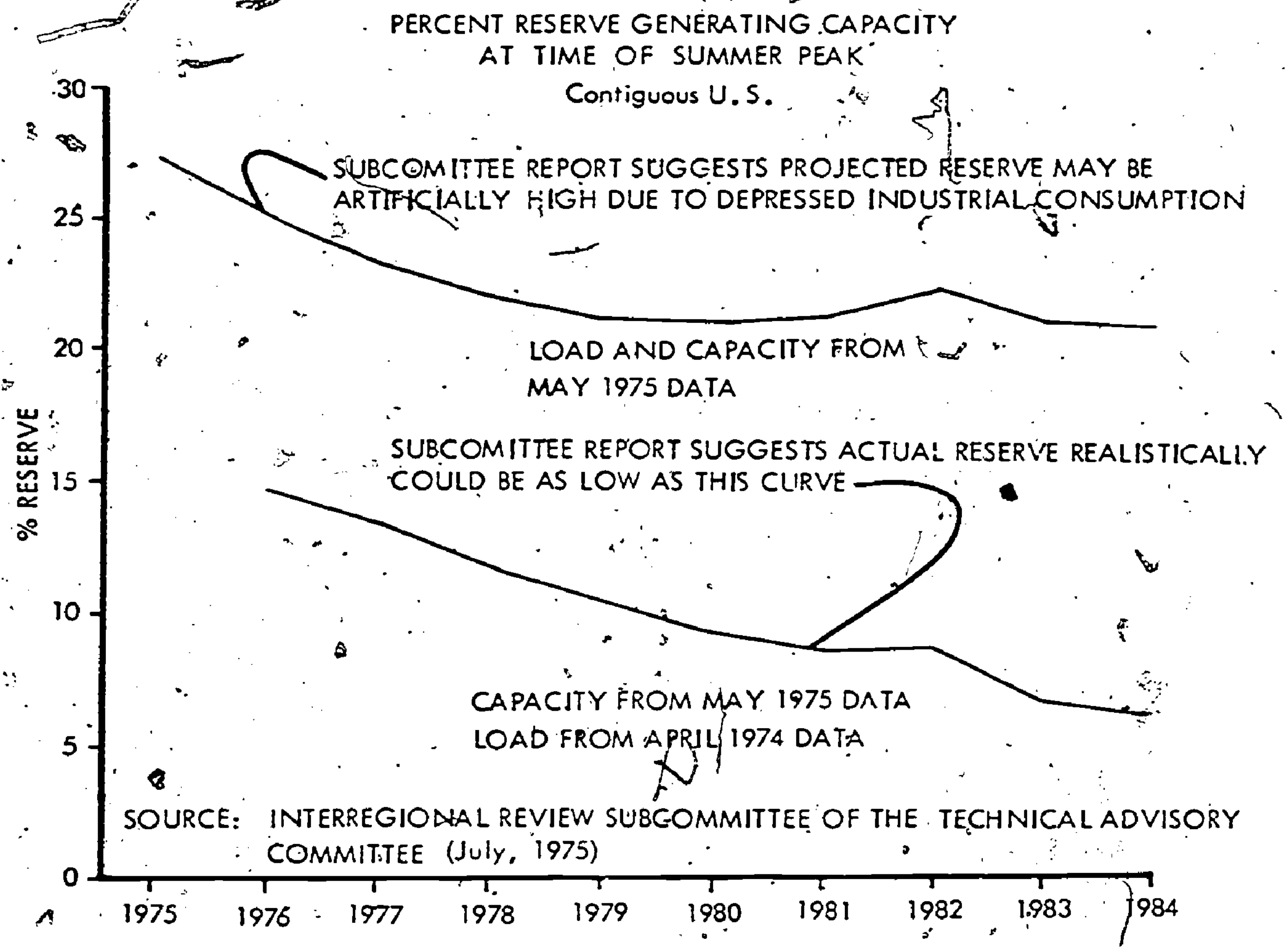
In the past, deficiencies in generating capacity often have been met by the installation of combustion turbines. This option is still open but the unavailability of gas and the limited availability of low sulfur oil makes the use of such equipment vulnerable -- even for peaking purposes. In addition, the lead time for the installation of such capacity has now increased to as long as three years so that combustion turbines no longer constitute a fast option for electric utilities to meet unexpected load increases or delays in generating equipment installations.



Source of data : EEI

PERCENTAGE CHANGE IN POWER USAGE BY USER GROUP.

FIGURE II-4



SOURCE: INTERREGIONAL REVIEW SUBCOMMITTEE OF THE TECHNICAL ADVISORY COMMITTEE (July, 1975)

FIGURE II-5

The intent is not to imply that the electric utility industry is performing less than commendably. On the contrary, since the turn of the century they have continued to supply reliable power at higher and higher efficiency. New technology was continually incorporated such as nuclear power and higher pressure and efficiency fossil units, all designed to provide more reliable and lower cost electricity.

The electric utility industry is caught in a situation beyond its control. They did not cause the Arab oil embargo, nor did they mandate the stringent environmental regulations imposed on them. They simply cannot afford to install power generation capacity beyond that which they can be reasonably certain that they can utilize -- and thus pay for.

Such sources of power supply as solar, geothermal, magnetohydrodynamics and wind do not provide options for significantly augmenting generating capacity during the foreseeable future. These energy sources require major research and development efforts before they can be considered to be viable alternatives to fossil and nuclear generation of electricity. The primary electric power for your institution will certainly be generated with conventional power generation equipment.

In view of the possibility that load forecasts might be low, the paucity of alternatives for effectively dealing with the consequences necessitates that contingency programs be established by institutions, such as yours, to insure availability of adequate electric power.

And so the cautions continue...The preceding paragraphs serve to illustrate the general feeling that prevails, namely, that at some juncture, power shortages may well become a reality. What is the answer? ---Is it on-site generation? Is it energy conservation? The problems are numerous, the contingencies vague, but one solution to this highly foreseeable dilemma could well be a concept known as the Integrated Utility System.

Impact on the Surrounding Community

When considering the appeal of the IUS concept, one must necessarily address the contingent effects on the surrounding community. Although the extent of effect is very much site-specific, physical, social, economic, service and aesthetic impacts will naturally be imposed on the local community to some degree. Initially the siting of the IUS is a factor; if the construction is on the perimeter rather than the center of a sprawling campus, then, obviously, the effects of contruction will be more noticeable to the surrounding community.

Existing Energy Plant

The type and condition of the existing energy generation and distribution arrangement can have a major effect on the payback period for an IUS. In cases where age and physical condition dictate the replacement or repair of major items such as boilers or steam distribution lines, then this, when properly reflected in the economic evaluation of implementing an IUS, will often result in a very attractive investment alternative where otherwise it may be marginal.

Institutional/Organizational

The number and type of institutional considerations vary widely depending on such factors as the number of community groups involved, state owned or privately owned university or hospital, interest of the electric grid in participating, and state laws pertaining to bonding and financing. Other, more specific problems relate to the ability of the staff to operate the more complex IUS hardware, the requirement to development new job descriptions and establish new wage categories, and the necessity to revise management and accounting systems to effect distribution and sale of services to customers. The marketing of the product in a multi-institutional arrangement could result in the IUS falling under the jurisdiction of state regulatory groups.

Economic Feasibility

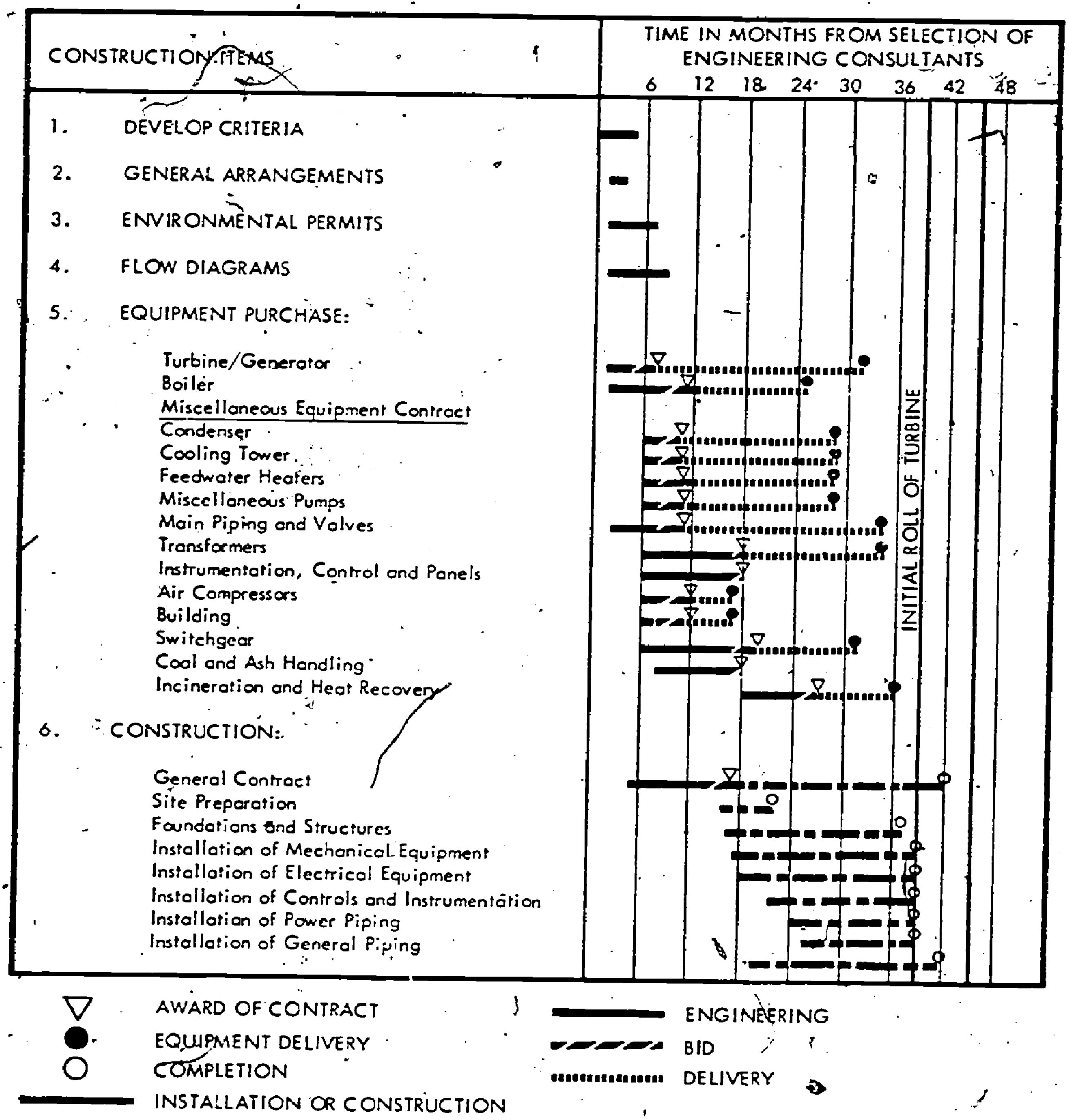
Although an IUS has overall economic advantages, competing alternatives for mission oriented projects, e.g. new library, could result in an IUS not receiving the endorsement required to insure implementation. In these cases, the self-liquidating nature of IUS needs to be emphasized. This could result in even more capital being available for more desirable mission related projects.

Even convinced of the economic desirability of implementing an IUS, the capital funds just may not be available, especially in the case of a private institution. One should then explore the case whereby the electric utility company servicing the area would own the generating system and sell electricity, steam and hot water. Other third party options may also be available.

In any case, it is imperative that the institution address the avenue for funding early and carefully plan the strategy for obtaining the necessary capital.

III. THE OPTIONS

FIGURE III-1
SCHEDULE FOR CONSTRUCTION
OF
INTEGRATED UTILITY SYSTEM AT UNIVERSITY OF FLORIDA



THE OPTIONS

The Planning/Implementation Cycle

The consideration of options may begin as the result of a significant event such as the constriction of an available fuel supply or perhaps simply through an awareness that the status quo is in jeopardy. Whatever the reason and whatever the frame of reference, be it cost, ecology or conservation, the IUS concept may afford the opportunity to improve the performance of a utility operation, either planned or existing.

To do nothing may be entirely inappropriate because of the trends in cost and availability of fuels. On the other hand, to do anything if it involves a change of any significance in the utility systems will probably require from three to five years in the planning and procurement process.

Clearly then, any institution which generates its own heat and has its own utility distribution system should assess its position now. At a minimum this should include a review of the institution's pattern of expansion in the use of fuel and electricity; a review of the national and regional trends in fuel and power price escalation and availability; consideration of existing contract agreements for utilities, assessment of existing or potential problems in land fill, calculation of the annual rate of increase of total utility bills; and a comparison of the proportion of utility costs to total budget now as opposed to three or four years ago.

With that information in hand and with knowledge of other institutional concerns and aspirations, it should be possible to make a reasonable conclusion as to the need for further consideration of the utility services problem.

If the IUS concept appears appropriate to your needs, what do you do next? Simply stated, investigate the elements of integration. What is called for at this juncture of your evaluation process is an in-depth feasibility analysis. The analysis will provide you with the means to accurately gauge the alternate subsystem alignments and their contingent benefits. This systematized monitoring process inevitably will clearly delineate where the bulk of the savings are evident. It may well be that your own site-specific optimization turns out to a partial IUS -- fine. Having conducted the feasibility analysis, reviewed the findings, agreed on the most productive alignment, what next? The answer...conceptual design. The conceptual design phase of your project allows you to view an identifiable product, namely, your on-site power generation and your optimized subsystem integration. The cost benefits suddenly become more meaningful, the potential more substantial. Your institution has now accomplished the first step in attaining the much sought after "security" should energy shortages become a reality. Funding and implementation follow.

As part of planning and effective program implementation, one should curtail utility system improvement programs to the extent practical when initiating an IUS feasibility study. The reason being that the utility structure most compatible with an IUS may not be that which is part of some on-going expansion or rehabilitation program. To continue with the expansion plan could result in a structure for which the economic feasibility is not viable. In any case, the postponement of improvements while completing the feasibility study should not be longer than four to six months.

The Existing System

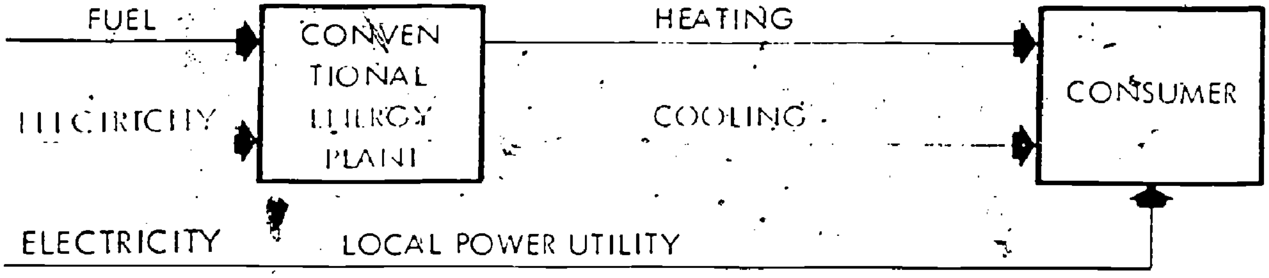
A thorough examination of the existing utility system is of prime importance in order to determine the level of subsystem incorporation that will provide the best economic return. To this end, the remaining operational life of the existing utility subsystems should be established, and the cost for their replacement determined. Because of the increased cost of energy, any piece of equipment nearing the end of its life expectancy might well stand replacement by machinery that has been specifically selected to provide improved thermal efficiency--possibly in the IUS structure. Compatibility with future planning is a major factor which adds to the appeal of the IUS concept. Major IUS subsystems can often be effectively integrated into an existing utility structure in a modular and incremental way. This results in a less capital-intensive implementation procedure and often a relatively short return on investment period.

In line with the main objectives of the IUS concept, namely, cost savings and energy conservation, the existing system should be carefully examined for excessive energy consumption. These losses can be quite large and the accrued benefits from correcting deficiencies can be substantial.

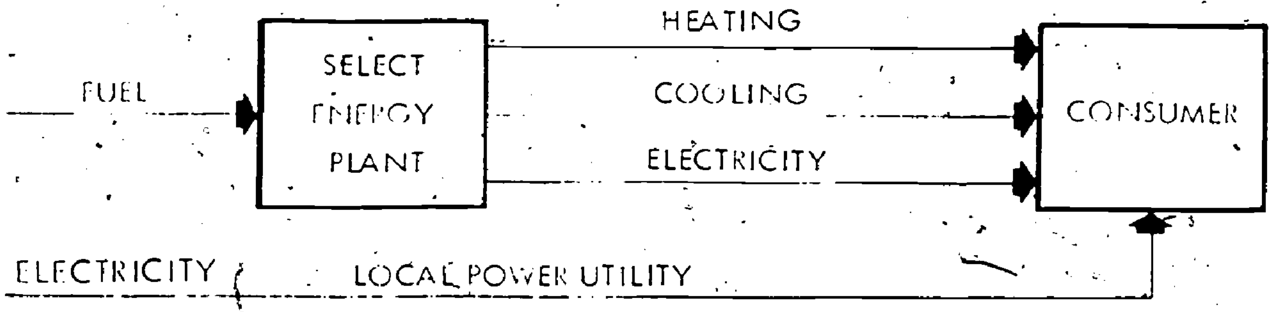
Energy conservation as such is an impetus state, in that recognition of initial wastages prompts investigation of other wasteful practices. In effect, we are advising that one never underplay the energy awareness attitude, as it is a vital prerequisite to a meaningful conservation program, particularly if the total system is kept in mind.

In a conventional utility system, the subsystems are for the most part considered to function separately from each other. Waste energy from each is rejected to the environment. In an IUS, these separate utilities are combined to reduce the total requirements for energy where possible by interchanging waste heat between utility subsystems, thereby reducing the overall adverse environmental impact and lowering the life cycle cost of the utility services.

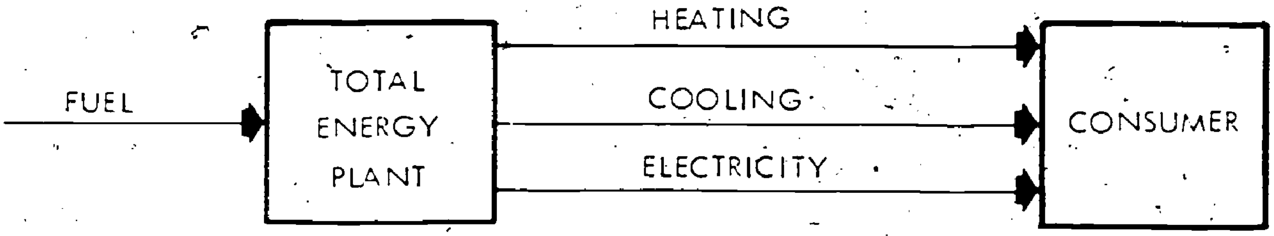
At this juncture, an identification of the basic differences between total and select energy systems, which are the key to a successful IUS, should be made. These systems are described schematically in Figure III-2.



CONVENTIONAL ENERGY SYSTEM



SELECT ENERGY SYSTEM



TOTAL ENERGY SYSTEM

FIGURE III-2
COMPARISON OF TOTAL, SELECT AND CONVENTIONAL ENERGY SYSTEMS

On-site electric power can be generated either completely independently or in parallel with the regional electric power supplier. Independent operation means just that. The electrical tie between the local supplier and your institution is severed. All necessary reserve and emergency capacity must be provided by your energy plant. If your demand exceeds generating capability, then you must shed electric loads or reduce voltage (brown-outs). This independent mode of operating is called Total Energy. An alternate mode is operation in parallel with the local electric utility. In this latter mode, the local utility provides all electric requirements over and above what you generate on-site including peaking and reserve requirements. The capital cost of maintaining this reserve capacity is paid for indirectly by the institution through a demand charge. The choice to own, operate and maintain the local reserve and backup depends, naturally, on a balancing of potential demand charges against self-maintained reserve costs.

In either system, if there is insufficient thermal energy available from electrical power generation, conventional boiler systems can be used to supply the deficiency. Highest efficiency of operation occurs when the recoverable energy from the electrical power generation matches the thermal energy requirements of the institution. For this reason, the maximum percent return on investment and the shortest payback period is going to come from select energy systems operating at full electrical capacity and utilizing all of the available thermal energy.

Subsystems as Key Components

As stated previously, the optimal situation would be perfect alignment of the electrical and thermal load of a facility. The probability of this condition ever prevailing is extremely remote; however, there are measures that can be taken to improve the alignment, such as energy management and energy storage.

Energy Management Systems (EMS) are well suited for IUS application. The state of the art is such that there are many proven systems available in varying degrees of sophistication for accomplishing a specific set of goals. Although an EMS normally controls a variety of parameters, the overall objectives are to reduce energy consumption, reduce capital costs, and reduce peak demand. Reducing peak demand results in a better uniformity in the ratio of electric power to thermal power.

Various modes of energy storage are commercially available and many more are under active development. The Energy Research and Development Administration (ERDA) has placed the development of new and improved energy storage systems as one of its major priorities.

The most likely storage media for thermal energy is water. The storage system would be charged during off peak hours, and discharged to its point of application during high heating or cooling demand periods. The benefit to the overall system is that the stored reserve allows an institution to meet higher thermal demands with less installed equipment capacity and at a higher overall system efficiency. This brief focus on the storage aspect of an IUS further highlights the magnitude of benefits associated with the concept.

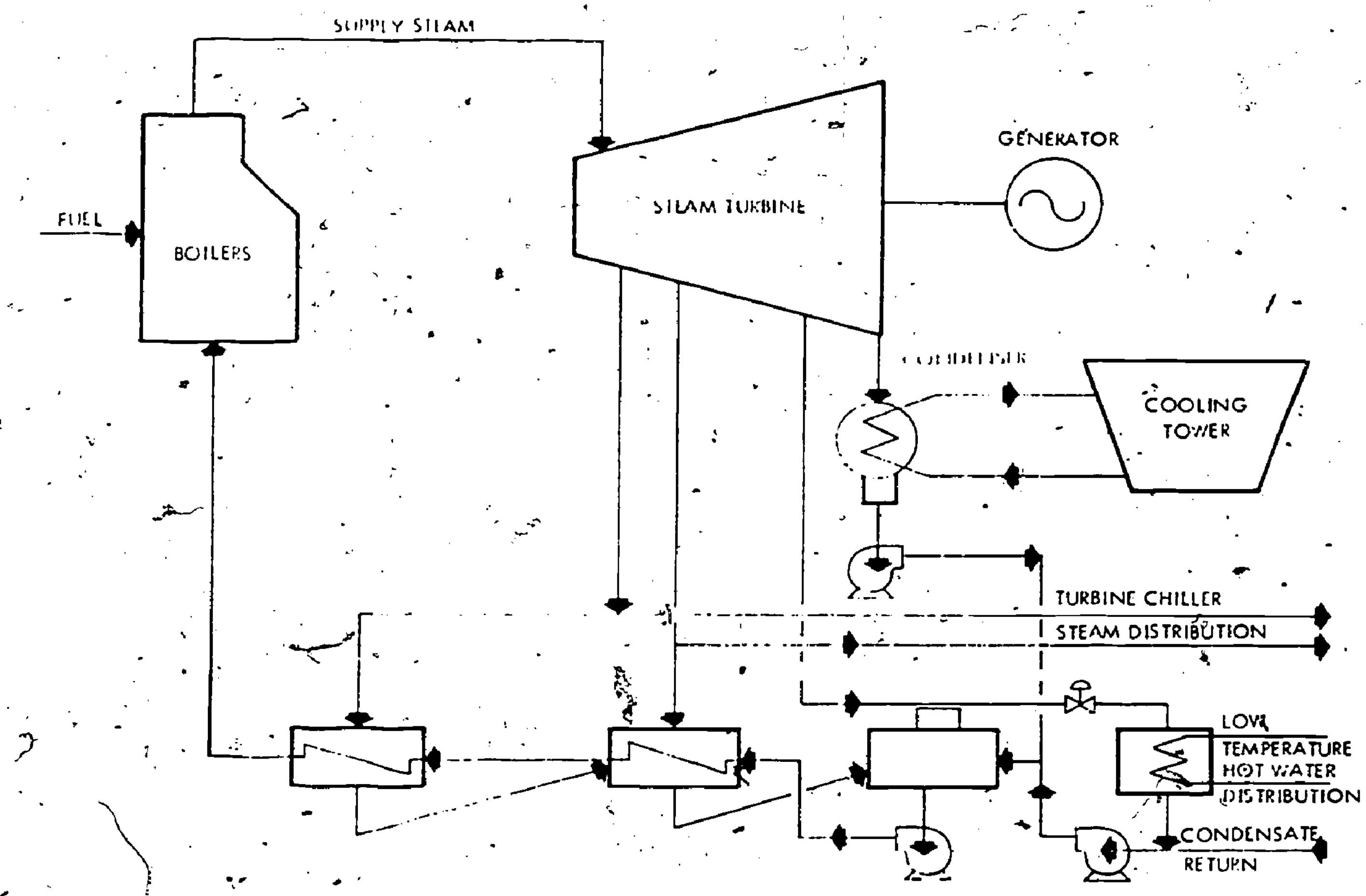
The main avenue to achieving the economic goals of an IUS is by reducing waste; therefore, the selection of hardware specifically to achieve this goal is a critical concern. Indeed, when in the process of evaluating past performance of existing equipment, be sure to temper your analysis on the conservative side. For example, it is common assumption that boiler efficiencies generally run in the range of 75 to 80 percent; in reality, however, this optimal condition rarely exists. Generally speaking, most institutional level plants maintain operating efficiencies of between 60 to 70 percent, and only then if they run continuously. If the system in question is cycled on and off, the effect on operating efficiencies can be significant. Indeed, a realistic estimate may even be as low as 50 percent. Realize that this condition is by no means an exception to the rule, and that many operating plants fail to reach even this modest plateau.

Having identified the need for the appropriate and conservative hardware selection, we should further define what form that equipment can necessarily take. The following is an encapsulated discussion of the available prime movers for power generation in educational and medical complexes.

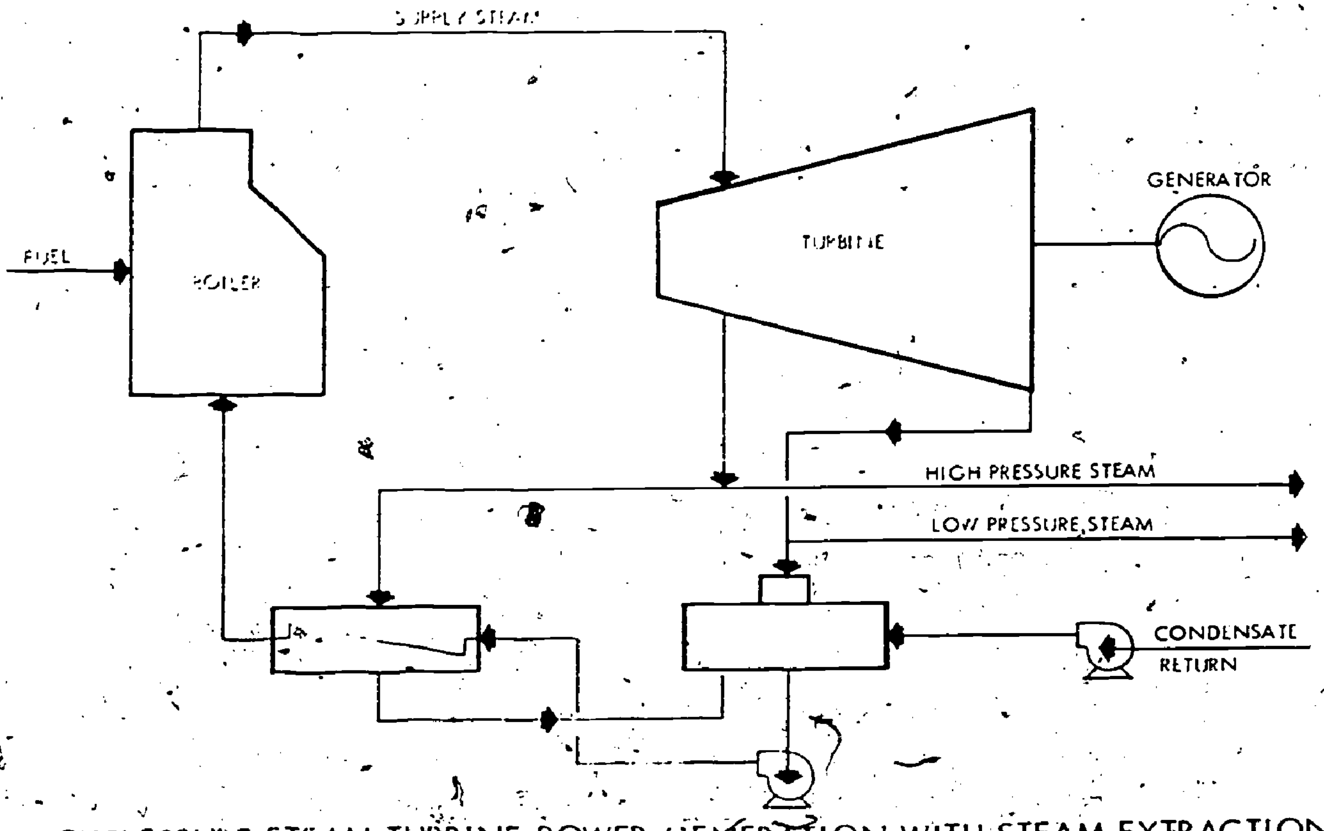
Naturally, the choice of prime movers for on-site electrical power generation will depend on the type of thermal distribution system, e.g. high pressure steam or low temperature hot water, as well as the ratio of power to heat requirements. In addition, the choice will also depend on the fuel availability, space availability, and environmental restrictions. Some systems will be very simple, others will consist of two or more prime movers and multiple combustion units. A major economic advantage of the IUS concept is the ability to effectively utilize existing subsystem configurations.

Steam Turbines

Simply stated, high pressure steam is produced by a boiler and then fed to a steam turbine generator unit. As the steam expands through the turbine, it pushes against turbine blades, turns a rotor connected to a generator whereby electrical power is generated. Steam turbines essentially are of two types, condensing and non-condensing. The condensing type discharges to pressures below atmospheric, requiring a condenser and cooling tower. The energy rejected to the cooling tower is ultimately wasted to the environment. The non-condensing (or back pressure) turbine operates at exhaust pressure above atmospheric. In principal, all of the steam can be utilized for heating, cooling or other process requirements.



CONDENSING TURBINE POWER GENERATION WITH MULTIPLE EXTRACTION



BACKPRESSURE STEAM TURBINE POWER GENERATION WITH STEAM EXTRACTION

FIGURE III-3

The choice of which type to select depends on the ratio of thermal to electrical loads that are to be supplied by the system. Figure III-3 illustrates both a condensing and a non-condensing steam turbine system. Steam is extracted at several pressure levels to supply various requirements, and feedwater heaters are incorporated to improve the overall efficiency.

For an IUS application, the steam turbine generator system has numerous advantages. The thermal efficiency of steam turbines for plants of the size required for educational and medical complexes is relatively high, they operate efficiently over a widely varying load, they are highly reliable and the operating and maintenance costs are low when compared to most other prime movers. A further significant benefit is the fact that the associated steam plants are well understood, and they can be readily designed to operate effectively on non-premium and more abundantly available fuels.

Reciprocating Internal Combustion Engines

The reciprocating engine, whether it is gas or oil burning, is generally recognized as one of the most efficient power sources available for on-site electrical generation in that its heat rate compares favorably with the best fossil fuel steam turbine generator units. The waste heat can also be recovered and used for satisfying thermal energy requirements of an institution. There are two types of reciprocating combustion engines in common use for power generation. One type is the diesel engine (compression ignition) which can use oils of various grades. The diesel is often designed to utilize both oil and natural gas, thus permitting the purchase of the most economically available fuel. Another type is a spark ignition such as the automobile engine which uses more expensive gasoline or high volatility fuels.

Internal combustion engines used as prime mover sources are called upon to deliver reliable, trouble free service for long periods of time. For this reason, large, slow speed engines operating in the 600 rpm range or less are preferable to small, high speed engines operating at 1,800 or 3,600 rpm. The slower engines experience less wear on the moving parts of the mechanism and are not as highly stressed throughout as are the high speed units.

Gas Turbines

Gas turbines are a third type of prime mover utilized for power generation. They have for many years provided service for peaking and backup units at large electric utility stations and as the principal source of power in such applications as universities and shopping centers where there is a use for waste energy. The principal of gas turbine operation is similar to steam turbines with the exception that combustion gases are expanded through the turbine rather than steam. Thermal efficiencies of gas turbines are lower than steam turbines. The overall system efficiency, however, can be improved significantly by placing a waste heat boiler on the discharge end of the turbine and using the recovered energy to provide thermal loads.

Combined Cycle

Efficiencies even higher than the simple cycle gas turbine system can be achieved by utilizing a combined cycle. The term combined cycle is given to the power system consisting of a gas turbine and a steam turbine combined in such a manner that the high temperature gas turbine exhaust is used to produce steam for a steam cycle. Generally speaking, there is sufficient thermal energy in the exhaust of a gas turbine to produce an additional 50 percent electricity with no additional fuel. The major manufacturer of combined cycle equipment launched an aggressive marketing program several years ago and, consequently, this concept is becoming quite popular throughout the country.

An option to the combined cycle concept described above is the variation where supplemental firing of additional fuel takes place in the heat recovery boiler for the steam turbine. This concept takes advantage of the fact that in order to limit the temperature of the combustion gases entering the gas turbine to values compatible with turbine blade material temperature limitations, considerable additional air beyond that required for complete combustion is introduced into the gas stream. There is sufficient excess air when combusted with supplemental fuel to generate an additional 50 to 100 percent electric power beyond that generated by the unfired system. The thermodynamic advantage results because this combustion air is approximately 800° F and does not have to be heated from ambient temperature.

The combined cycle variations offer additional alternatives in optimally satisfying the important ratio of thermal to electric energy requirements.

The preceding paragraphs have provided an overview of the various prime movers associated with on-site power generation. Of necessity, the characteristics of existing facilities, utility loads and energy source availability will have a major influence on the options available in a site-specific instance. In evaluating which options can be best used in an IUS, certain criteria should be followed, such as the potential for amalgamation with other subsystems, system efficiency and lastly, a prime factor, capital cost. Although the demonstration of the advantages of the IUS concept has been based on proven technology, this does not preclude a given institution from implementing advanced technology subsystems in an IUS. The IUS concept is compatible with new technology, and new technology can generally be readily incorporated into a new or on-going system. A prime example of this incorporation would be solar heating to augment the thermal loads.

We shall endeavor from this point onward to define the subsystem structures along with the options for integration that are immediately evident. A point that cannot be overstressed is that optimal forms of IUS are very much site-specific. Further, it is not always the case that optimization results from integration of all the subsystem configurations. The economics of various subsystem alignments will determine just how feasible a proposed integration might be. Indeed, in some instances contingent benefits will assume a diminishing return status after the initial integration of the power generation and space conditioning subsystem utilities. If this is the case, your objective will have been attained in that your institution will be operating in as efficient and cost effective a manner as is practical.

Heating and Cooling Subsystems

Heating and cooling requirements on a university campus or in a hospital are generally distributed to the end use as steam or hot water. This can be either high pressure or low pressure steam or high temperature or low temperature hot water. The higher the pressure or the higher the temperature, the smaller the distribution line sizes and, thus, the lower the distribution system capital costs. However, in an IUS the higher the pressure and temperature, the greater the loss in potential for producing electric power. It just so happens that in many institutions, at the point of end waste, the steam or water is converted to a relatively low temperature before being utilized for comfort loads. Thus, if the distribution system could accommodate or be modified to accommodate low pressure steam or low temperature hot water, a significant economic advantage could result. An examination of selected sites has shown that conversion to low temperature hot water or a reduction in the distribution pressure is a definite possibility. Another alternate results from the fact that many institutions have a continual on-going utility system upgrading program which includes distribution lines. Conversion to low temperature or low pressure distribution could be incorporated into that program.

The cooling loads of universities or hospitals have an annual cycle which peaks in the summer and is minimal during the winter. If electric motor-driven centrifugal chillers are used to provide cooling, the peak electrical demand by these machines will occur during the summer when heating load requirements are minimal and the waste heat can not be effectively used. If absorption chillers are used, operating off of waste heat from power generation, there will be a better balanced electrical demand, resulting in a significant improvement in the overall system efficiency.

Solid Waste Management

The solid waste generated by an institution can often be utilized to advantage in an IUS structure. The fraction of recoverable energy from the incineration of the solid waste will be in the average range of 5 percent of the fuel requirements for heating and cooling. In addition, the solid waste will be reduced to approximately 5 percent of its original volume and will be in the form of a sterile residue, greatly reducing landfill requirements. Further, should the IUS incorporate a coal fired boiler, the disposal of this ash, also a very sterile residue, can be accomplished in a conventional landfill or it could be used as a fill material.

By far the simplest approach to heat recovery from incineration is providing low pressure steam for heating and cooling purposes. This approach fits in quite well with a diesel or gas turbine where there is often a deficiency in thermal energy available from the electrical power production.

A highly effective method for introducing the energy recoverd from the incineration of solid waste into the steam power cycle is by preheating the boiler feedwater either in an economizer or in a high pressure feedwater heater. In this approach, the recovered energy from solid waste incineration is captured at a higher quality (temperature and pressure) and much greater advantage is taken of the thermodynamic availability of the hot incineration gases. Preprocessed solid waste could be supplementally fired in a coal fired utility type boiler. Preliminary conclusions indicate ~~that~~ supplemental firing in the range of 10 to 15 percent of the total Btu input may be supplied by municipal solid waste (MSW) with minimal problems.

In order to take advantage of the economies of scale in utilizing solid waste, an institution may wish to incorporate the wastestream from an adjacent community. There are a multiplicity of institutional and jurisdictional factors which must be addressed prior to such an incorporation. Not the least of these would be possible realignment of collection areas, along with guaranteed uniformity of service and rate schedules. These, plus a number of other considerations too numerous to cover herein, should be subject to careful evaluation.

Water Management

Water must be supplied to an institution for human consumption, makeup for various utility services, and irrigation. The supply source can either be provided from local surface or well water or it can be imported from some external supply. Likewise, wastewater must be disposed of consistent with appropriate environmental requirements. An objective is to economically use the supply water and reuse the wastewater in such a manner that water is conserved, and there is a minimal negative environmental impact. Possible uses of treated wastewater that would save potable water are power plant makeup, cooling tower makeup, scrubber makeup and irrigation--in fact, almost any potable water application with the exception of human consumption.

The central theme in water management, other than drinking water, is to use the minimal quality of water which satisfactorily meets the needs of the intended use. Similarly, the treatment level need only be sufficient to satisfy the requirements of the specific use. The potential exists for an IUS using renovated wastewater in such non-human contact purposes as cooling tower makeup, flue gas scrubbers, irrigation, and fire protection.

As has been stated earlier, the success of the IUS depends on the level to which specific subsystems can be efficiently integrated. The cascading of energy from one subsystem to the next, rather than rejecting the energy to the environment, is the element that affords the potential for savings. This chapter has sought to indicate to the reader the structure of existing utility subsystems, and to delineate some of the options available to bring about optimal realignment under the structure of the IUS concept. If there is a major advantage evident, it is that the requisite IUS technologies can be implemented immediately. This indeed is the very heart of the IUS concept, namely...the effective utilization of proven technology.

IV. UNIVERSITY OF FLORIDA AND CENTRAL MICHIGAN UNIVERSITY

THE UNIVERSITY OF FLORIDA AND CENTRAL MICHIGAN UNIVERSITY IUS EXPERIENCE

In order that the reader might relate to his own institution, the experience from the encapsulated documentation of the findings of the IUS feasibility studies of the University of Florida and Central Michigan University utility systems are included.

Starting with the knowledge that each solution must be tailored to the site, the following recommendations resulted. The recommended approach for the University of Florida consists of coal fired steam turbine generators operating as a Select Energy system and providing up to 85 percent of the electric power requirements. The recommended system for Central Michigan University is also a coal fired plant with a steam turbine generator producing 100 percent of the campus electrical energy requirements. This recommendation is a Total Energy system and, as such, complete backup of the power generation system will be required. The existing heating plant will provide standby thermal generating capacity.

The University of Florida, Gainesville, Florida

The University of Florida, which has a student body of 28,000, affords a large but contiguous site with appropriately large electrical and thermal loads. In fiscal year 1974/1975, 120 million kilowatt hours and 984 million pounds of steam were purchased and generated respectively. The vast majority of the electricity was purchased from a local utility, Florida Power Corporation. All of the steam was generated with gas/oil fired boilers in the institution's existing system. A feasibility study on the potential for an IUS at the University of Florida resulted in the following observations:

- An IUS at the University of Florida is attractive, offering significant utility operation and maintenance savings. The proposed IUS design at the University has a payback period of less than 5 years starting from date of operation.
- The present worth at 6.5 percent, the payback period, and the interest rate of return on the investment for the recommended system is $71 million, 4.7 years, and 23.3 percent, respectively.
- An IUS reduces overall utility operations costs. The University of Florida baseline operating costs amount to $10,017,000 (1981 dollars), while the proposed IUS design operating costs are estimated at $5,967,000. This represents a net annual savings over the baseline case of 40 percent.

- An IUS can generate a significant portion of the required power. For the University of Florida, 85 percent of the electric power will be provided by the recommended JUS.
- Solid waste incineration with heat recovery and waste volume reduction are advantages derived from an IUS.
- A low temperature hot water distribution system can be incorporated into an IUS to provide significant additional energy and cost saving advantages and a payment on that increment of less than one year.
- It is not necessary to implement a completely integrated utility to benefit from the concept of an IUS. Substantial benefits can be accrued by partial integration, thereby permitting phases of the investment.
- An IUS can be compatible with an on-going utility system expansion program.

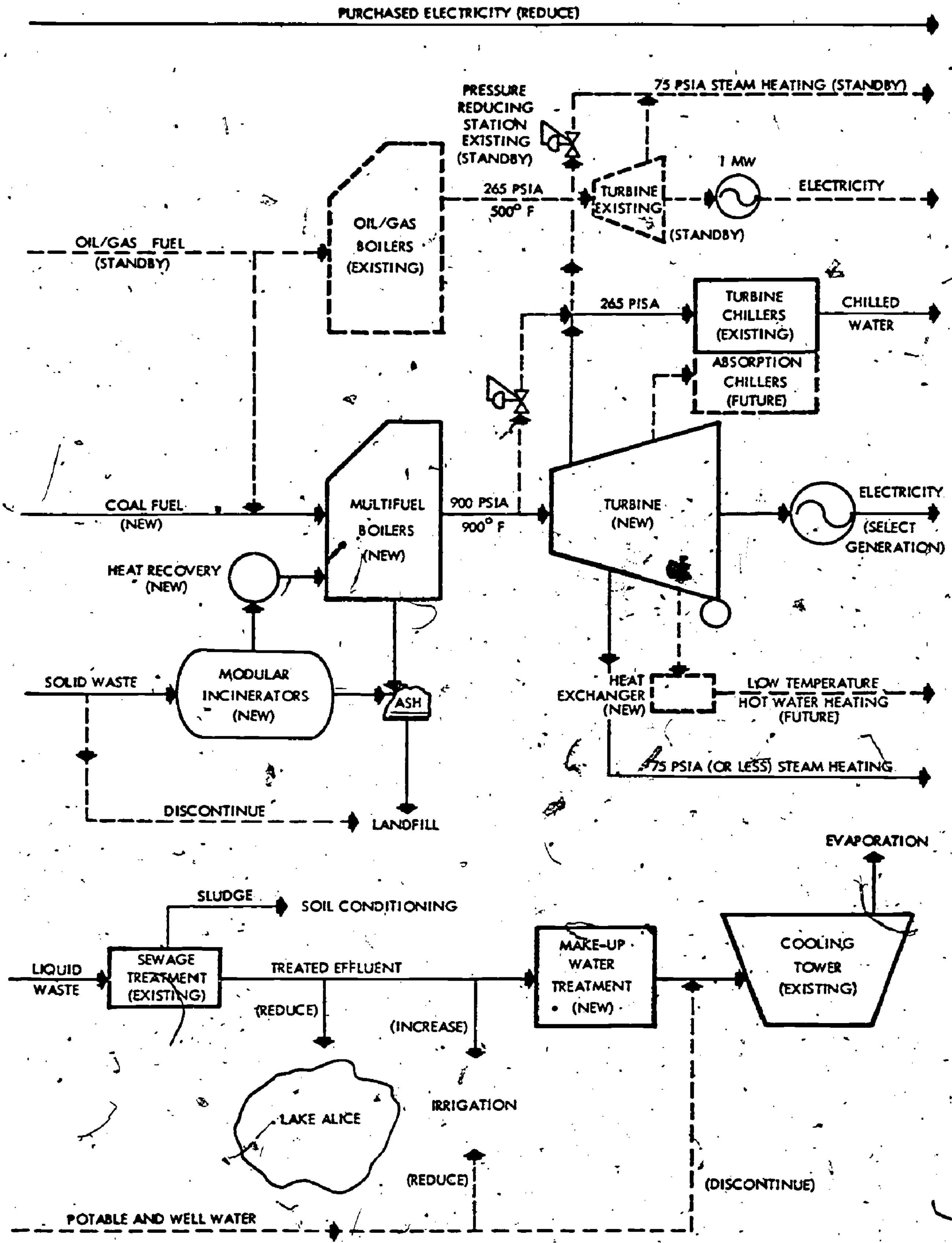
The proposed Integrated Utility System at the University of Florida is shown in Figure IV-1. The utilities provided for in the integrated system are electricity, heating and cooling, wastewater treatment, and solid waste management. The only utility not provided for by the IUS is potable water. The University will purchase this utility from the city although on-site production has been under consideration for several years. The treated effluent for the sewage facility is to be used for irrigation and cooling tower makeup.

Central Michigan University, Mount Pleasant, Michigan

Unlike the University of Florida, which has a relatively large utility system, Central Michigan's only utility service is the production of steam to meet the heating and cooling demands of the campus. The University encompasses 862 acres and has a student population of 16,000, of which approximately 7,000 reside on campus. The weather at Central Michigan University is rather severe and the central heating plant produced 350 million pounds of steam in fiscal year 1974/1975. The maximum steam demand experienced was 125,000 pounds of steam per hour. Electrical consumption for the same time period was a relatively low 24.1 million kilowatt hours. The maximum electrical demand experienced was approximately 5,000 kW. All electricity is purchased from the Consumers Power Company. The primary fuel of the boiler plant is natural gas from domestic and Canadian sources.

The results of the IUS feasibility study performed on Central Michigan University resulted in the following conclusions:

- An IUS facility is feasible at Central Michigan University.



INTEGRATED UTILITY SYSTEM
UNIVERSITY OF FLORIDA

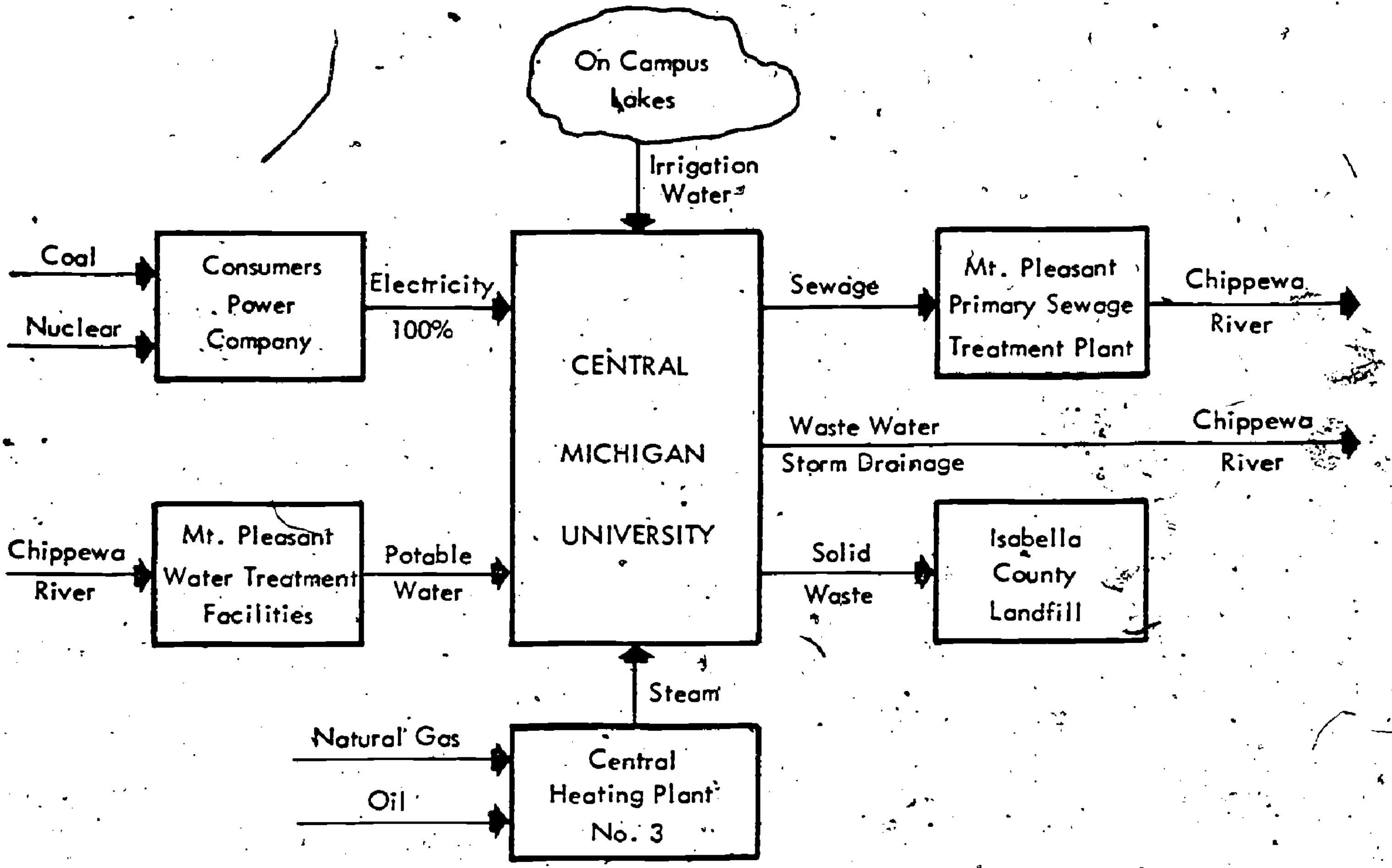
FIGURE IV-1

- The present worth of the net savings at a 7 percent discount rate, the payback period and the interest rate of return for the recommended system are, respectively, $9,177,000, 11.4 years and 12.5 percent.

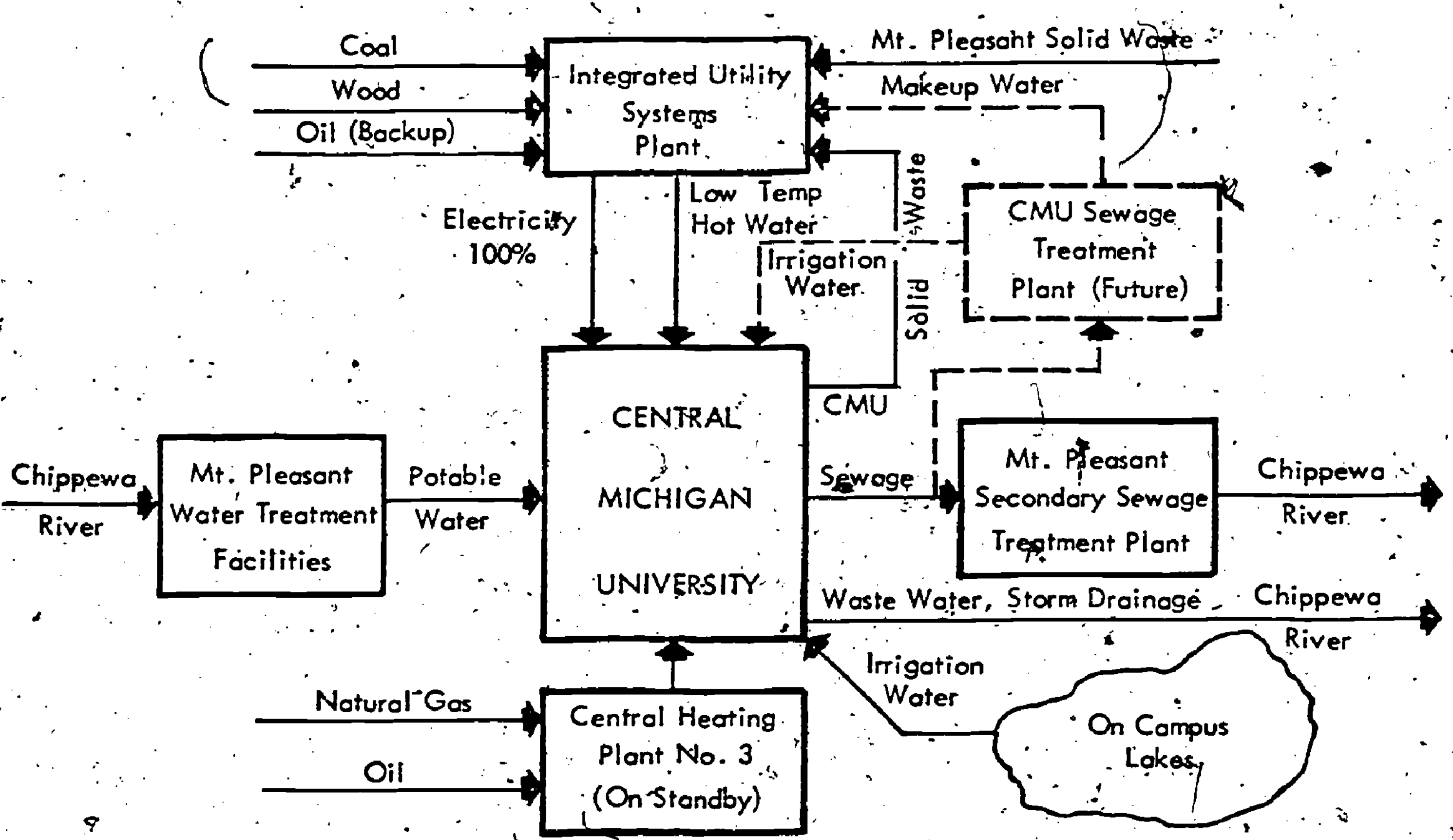
- The cost of utility operations will be reduced by the implementation of an IUS at Central Michigan University. The existing system baseline operating costs are $2,354,000 (1981 dollars). The proposed IUS design operating costs are estimated at $1,133,000, representing a net annual savings over the baseline case of 51 percent.

- Incineration of municipal solid waste from Central Michigan University and the City of Mount Pleasant was found to be economically viable and will result in the displacement of 13 percent of the annual high grade fuel requirements.

The existing utility system and recommended IUS facilities are shown in Figure IV-2. The IUS facility will initially provide power generation, heating and cooling and solid waste incineration with heat recovery. A subsystem for future integration is a selective sewage plant sized to produce enough treated effluent to meet the makeup and irrigation water requirements of the boiler plant and campus, respectively.



EXISTING CMU UTILITY SYSTEM



INTEGRATED UTILITY SYSTEM – TOTAL ENERGY PLANT
FIGURE IV-2

CONCLUSION

The increasing cost and importance of providing reliable utility services to educational, medical and municipal communities undoubtedly requires the enlightened attention of planners, administrators, builders, and operators of utility systems serving these facilities. The implementation of the Integrated Utility System concept can substantially reduce the costs of providing these services while conserving energy and yet meet the various imposed environmental and institutional constraints.

The potential for a successful IUS installation exists throughout the country. Every utility system in the United States has, in varying degrees, been adversely affected by the rapid increase in costs and decreasing availability of one time plentiful fuel sources. Faced with the spectre of outright curtailment of some types of fuel, the capability of being able to fire a number of various types of fuel becomes increasingly more attractive. In addition to fuel availability, the traditional method of solid waste management, namely, the landfill concept, is also under fire as the availability of usable land decreases and costs increase. Also, the awareness of the energy potential contained within the wastes has shown that simply disposing of the residue is tantamount to burying substantial amounts of money that could be recouped by incineration with heat recovery or a materials recovery operation. The heat recovery or resource recovery operation would reduce the amount of waste that would ultimately have to be disposed of, thus saving the land.

IUS, by its generic nature, does not connote any one set of hardware, but rather it is a concept which provides the fundamental basis for selecting and integrating utility subsystems with a view to providing a better overall system performance. Hence, the fundamental concept of an IUS can optimally serve as a basis for the long range planning and upgrading of existing facilities. Furthermore, as was mentioned earlier, it is not necessary to implement a completely amalgamated utility system to benefit from the concepts of an IUS. Substantial benefits can be accrued by partial integration, the implementation of which can often be made as part of the on-going utility system program at a given institution.

The attempt throughout this Guide has been to realistically identify the potential benefits to be gained from implementing an IUS. It is apparent that the incentives are there.

In the event that the reader has defined that an area of mutual interest exists, the source point of further information on the generic IUS concept would be:

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