GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: March 21, 1979

Project Title: Terrestrial Energy Research Requirements Assessment

Project No: A-2341

Project Director: R. A. Cassanova

Sponsor: Southeastern Center for Electrical Engineering Education, Inc. (SCEEE)

Agreement Period: From 12/1/78 Until 9/30/79

Type Agreement: Subcontract No. SCEEE-SIP/78-32 under US Gov't. Prime F33615-77-C-2059

Amount: $12,331 SCEEE
1,370 GIT Cost-Sharing E-102-301
$13,701 Total

Reports Required: Quarterly Technical Reports; Final Technical Report

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Defense Priority Rating:

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GEORGIA INSTITUTE OF TECHNOLOGY
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Date: February 25, 1980

'roject Title: Terrestrial Energy Research Requirements Assessment

'roject No: A-2341

'roject Director: R. A. Cassanova

ponsor: Southeastern Center for Electrical Engineering Education, Inc. (SCEEE)

ffective Termination Date: September 30, 1979

learance of Accounting Charges: September 30, 1979

rant/Contract Closeout Actions Remaining:

TERMINATED

- x Final Invoice and Closing Documents
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other ______________________

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CA-4 (1/79)

FINAL TECHNICAL REPORT

Period Covering December 1, 1978 to September 30, 1979

TERRESTRIAL ENERGY RESEARCH
REQUIREMENTS ASSESSMENT

Project Director: R. A. Cassanova
Lab Director
Energy Research Laboratory

under

The Southeastern Center for Electrical
Engineering Education, Inc. Subcontract
No. SCEEE-SIP/78-32 under U.S. Government
Prime F33615-77-C-2059

by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30322

January 1980

FINAL TECHNICAL REPORT

Period Covering December 1, 1978 to September 30, 1979

TERRESTRIAL ENERGY RESEARCH REQUIREMENTS ASSESSMENT

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Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30322

January 1980

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INTRODUCTION

TERRESTRIAL ENERGY RESEARCH REQUIREMENTS ASSESSMENT

On November 9th and 10th, 1978, a meeting was held at Georgia Tech with representatives from Wright-Patterson Air Force Base and Tyndall Air Force Base for the purpose of defining and characterizing the nature of the Air Force terrestrial energy problems and analyzing potential R&D responses. Based on the discussions during this meeting, a group of program summaries were prepared by personnel of the Georgia Tech Engineering Experiment Station and are included in this document.

EVALUATION OF SOLAR ASSISTED

HEAT PUMPS FOR RESIDENTIAL HEATING

SOLAR ASSISTED HEAT PUMP

Basic Concept

Heat pumps offer the potential for increasing the efficiency and economics of solar heating systems. Frequently solar heating systems are unable to meet heating requirements because storage temperatures have dropped to levels too low to heat directly from storage. This limiting temperature is between 105° to 110° F. Water source heat pumps are capable of efficiently extracting energy from storage down to temperatures below 50° F. Through the use of heat pumps, storage capacity of active solar heating systems can be increased by 75% to 100% without increasing the storage volume.

Figure 1 presents a basic solar assisted heat pump system as used to heat and cool residential buildings. Energy from the solar collector is provided through a glycol-water to water heat exchanger to heat the storage and then through a water to air heat exchanger to heat the home when the fluid temperature is above 110° F.

When the temperature is between 80/85° F and 110° F, the water from storage is pumped through the heat exchanger to partially heat the air. The water leaving the heat exchanger is then taken to the evaporator of a water source heat pump which further extracts energy from the storage water. The energy collected by the heat pump is discharged to the partially heated air at a second heat exchanger or through separate passages in the same heat exchanger.

When the storage temperature drops to approximately 80° to 85° F, very little air preheating is accomplished by the storage fluid directly, but the heat pump can still extract energy efficiently until the storage temperature reaches approximately 40° to 45° F. When storage temperatures drop below the 40° to 45° F limit, auxiliary energy systems, such as electric resistance heaters, must take up the load.

The large storage volume required by such solar heating systems could be put to good use during the cooling season by operating the heat pump with an outside coil during the night when ambient temperatures are lower

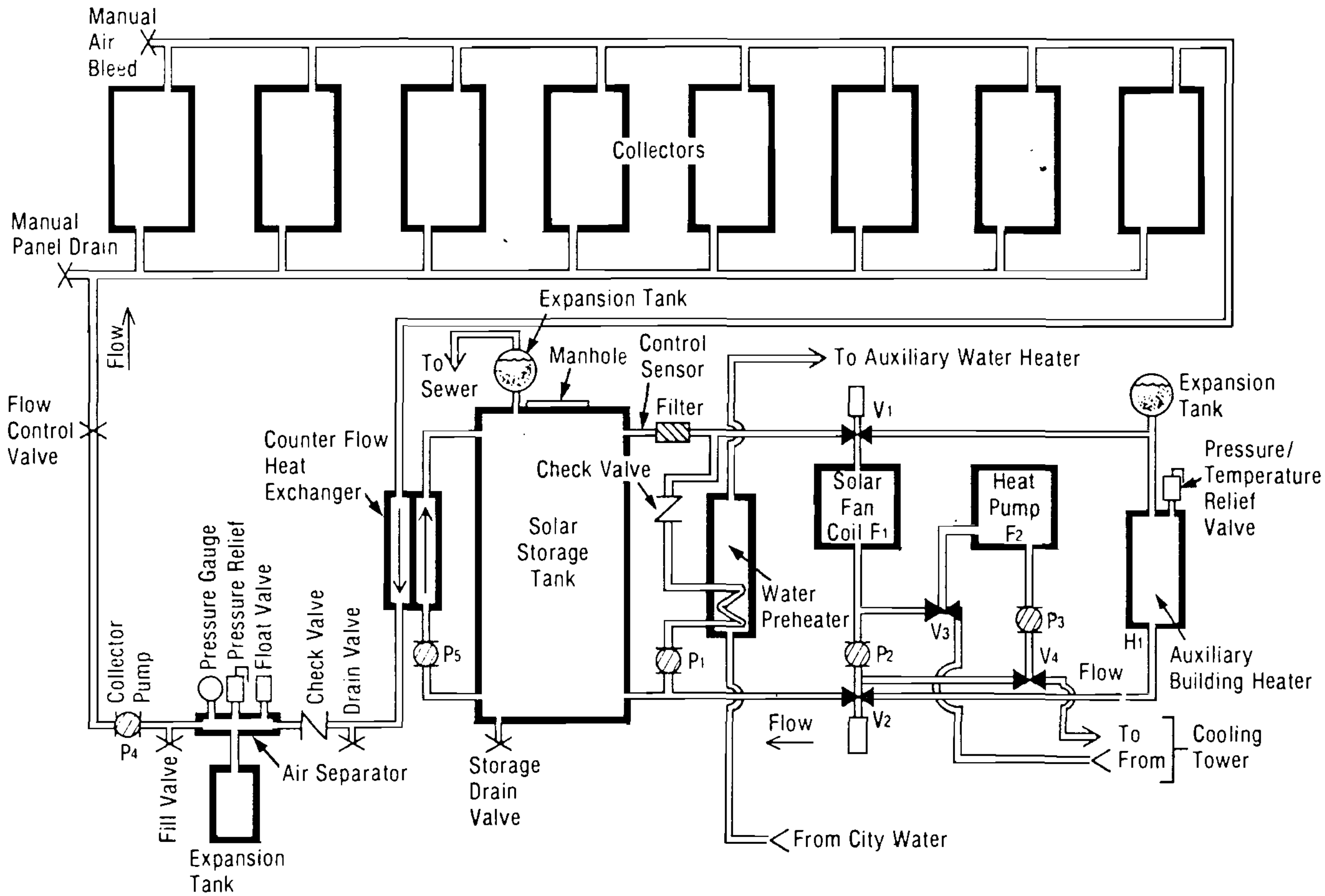


Figure 1. Solar Assisted Heat Pump With Cooling

and during off peak hours of the electric utility. The heat pump is used to cool the water in the storage tank at night and the water from the storage tank is then used to cool the house during the daytime when cooling is required. (This is not shown in Figure 1.)

Application Areas

Solar assisted heat pumps are applicable in all areas where direct solar heating systems are applicable. They are especially attractive relative to direct solar heating systems in those areas where there is a requirement for substantial cooling and when used with the outside coil in those areas with mild nights or with electric utilities which give an off-peak price break.

As with all solar heating systems, they are the most competitive from an economic standpoint when competing with electric resistance heating. It is proposed that the principal application to be studied would be the 420 electric resistance forced air residential units in the "New Area."

Relative Benefits

The principal benefit to be expected from solar assisted heat pumps is the significant reduction in energy consumed and in electrical load when compared to electric resistance heating. A secondary benefit is the improvement in solar collector efficiency when used with a heat pump due to the system's capability to operate at a lower temperature. This permits both a reduction in collector area and storage volume.

Another benefit of solar assisted heat pumps is the increased cooling efficiency and lower operating cost possible by operating the heat pump only at night using off-peak power.

Proposed Program

It is proposed that the program be composed of the following five tasks:

Task I - Technical Study and the Preliminary Design

This study will establish the solar assisted heat pump potential for the Wright Patterson New Housing Area, and the year-round performance effectiveness of the solar assisted heat pump. It will determine the relative performance of liquid solar collectors with water source heat pumps compared to air solar collectors with air source heat pumps and will establish a "base case" existing house load and determine the load displacement if operated with a solar assisted heat pump.

Task II - Definitive Design

This phase will provide a definitive design, including drawings and specifications for the installation of a solar assisted heat pump into one of the housing units within the 420 unit complex. This will include the design of the instrumentation package to acquire the data needed to quantify the performance of the system.

Task III - Procurement and Construction

This phase will procure and construct (install) the single unit including the instrumentation. The effort will consist of supporting Wright Patterson Air Force Base personnel in the procurement and management of the installation.

Task IV - Startup and Initial Operation

The task will consist of startup, checkout, adjusting and initial operation to insure that the system is operating reliably and in a manner which will optimize performance. Instrumentation performance will be verified and the data necessary to verify the system's performance with predictions will be collected and analyzed.

Task V - Long Term Operation and Performance Analysis

This task will consist primarily of data reduction, analysis and reporting. Its objective will be to quantify and document the system's performance and compare it with the predicted performance.

Schedule

The bar chart shown in Figure 2 gives the duration and timing of each phase.

PERFORMANCE SCHEDULE FOR SOLAR ASSISTED HEAT PUMP
PROGRAM FOR WRIGHT PATTERSON AIR FORCE BASE

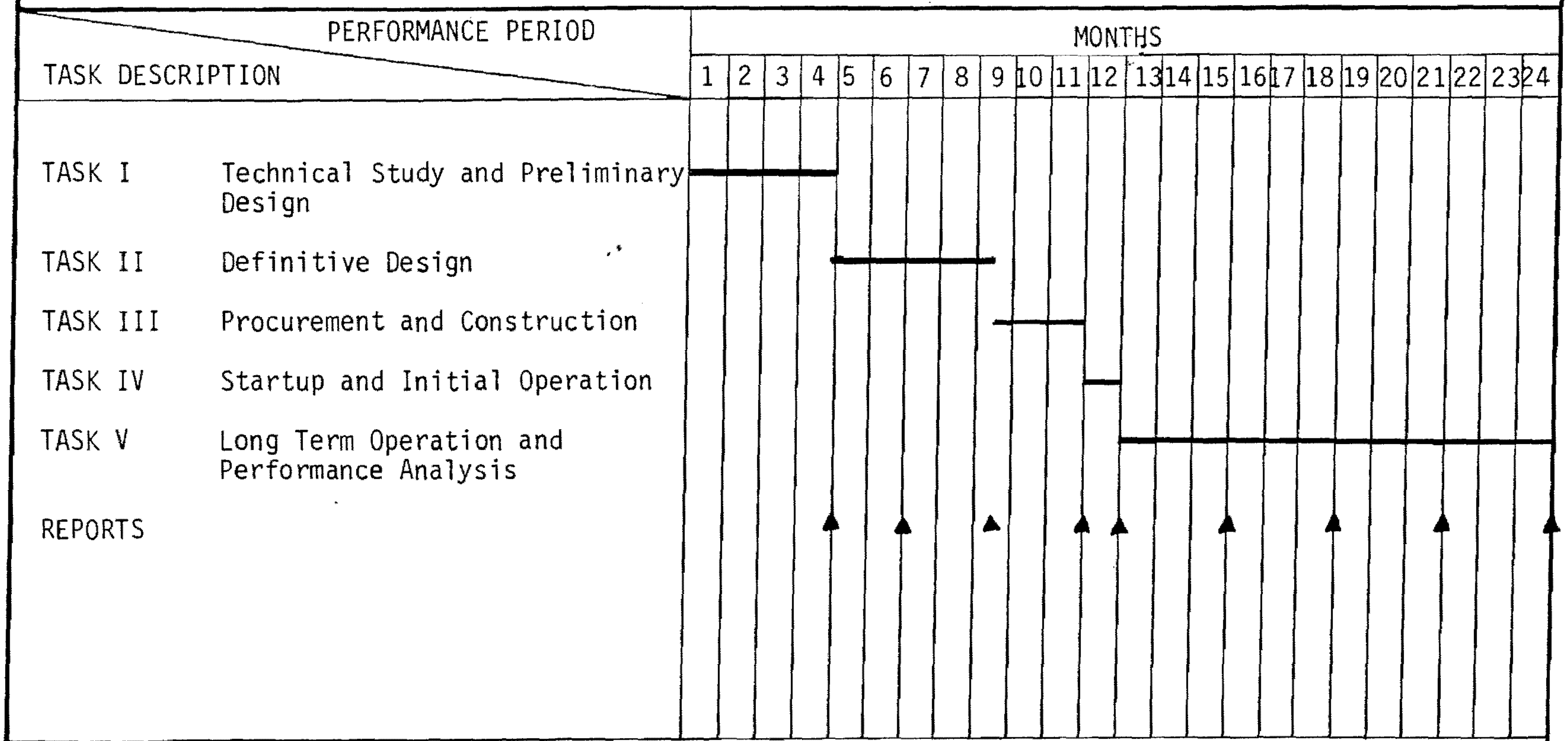


Figure 2

Budget

The budget outlined below is an estimate of the cost of the five tasks including reporting:

Task I	$ 30,000
Task II	25,000
Task III	25,000
Task IV	15,000
Task V	20,000
Total Estimated Budget (24 Months)	$115,000

EVALUATION OF WATER SOURCE

HEAT PUMPS FOR RESIDENTIAL HEATING

WATER SOURCE HEAT PUMPS

Basic Concept

"Water Source Heat Pump" is a name applied to a year-round air conditioning system which extracts heat from water when in the heating mode and gives heat to water when in the cooling mode. Water source heat pumps are usually electrically driven and work on the same principal as all electrically driven reversible air conditioners. Unlike air conditioners and air source heat pumps, water source heat pumps can maintain a high efficiency when ambient temperatures are very high and very cold since the "source" and "sink" temperatures are "high" and "low," respectively, relative to ambient conditions. This is important because unlike air source heat pumps, water source heat pumps are capable of delivering maximum performance during those very hot or very cold periods when the maximum exchange is needed.

Figure 1 is a schematic of a water source heat pump in the heating mode. Only the reversing valve is actuated to switch from the heating to cooling mode. This valve is switched electrically from a centrally located thermostat. Energy is exhanged with water which may come from ground loops, lakes, ponds or shallow wells. If ground water is readily available, shallow wells have proven to be the most reliable source of water. Water requirements typically are about 3 GPM per ton of cooling.

Application Areas

Water source heat pumps are readily available at all locations where there is an adequate supply of water at temperatures above 45°F that is readily accessible by shallow wells. Figure 2 shows that ground water temperatures at Wright-Patterson are between 52° and 54° F.1/ Work currently underway on a Department of Energy program in Greenbriar, Virginia where the ground water temperature is approximately 62°F has shown the annual energy consumption of homes using ground water heat pumps

UNIT HEATING MODE

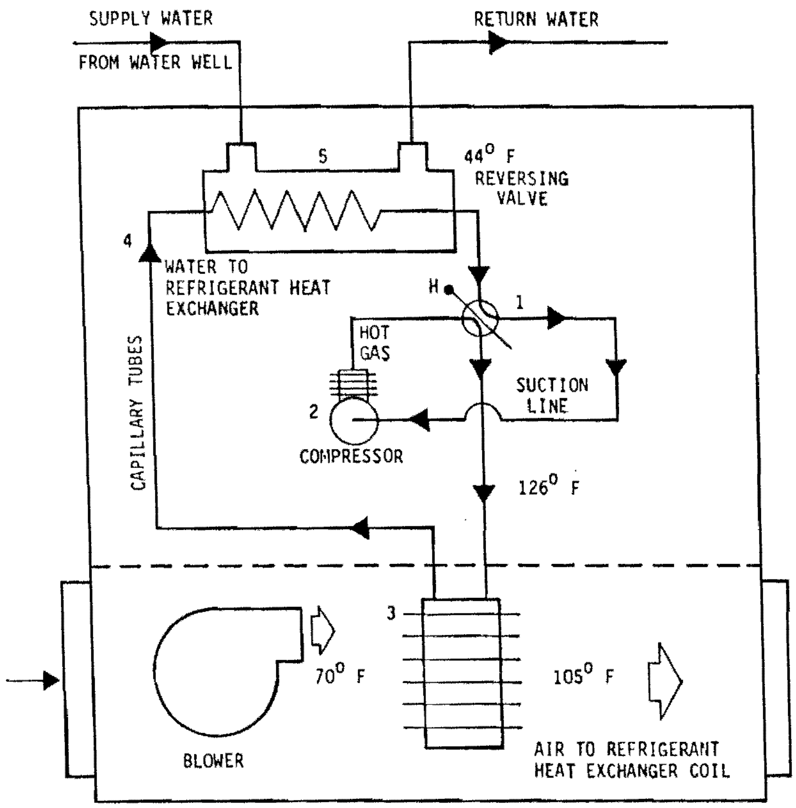


Figure 1 Water Source Heat Pump

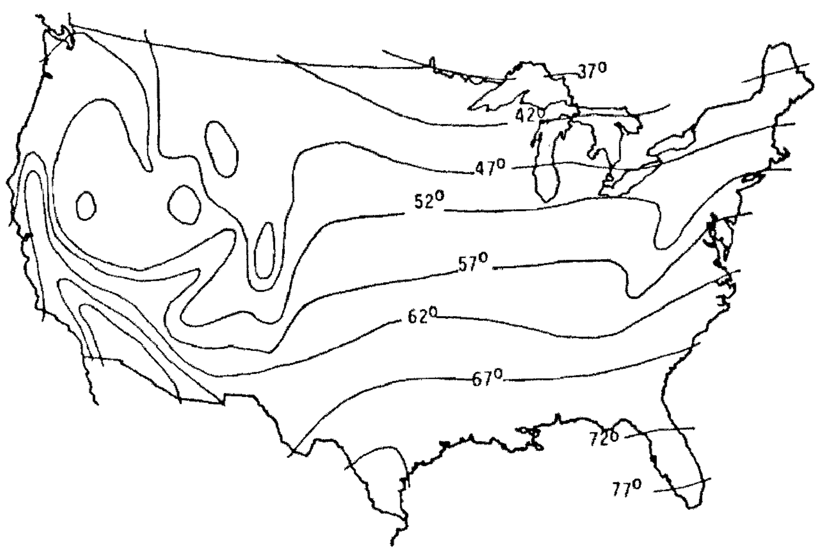


Figure 2 Average Temperature of Shallow Ground Water (degrees F)

can only be 30% to 40% of the energy consumption when heated with electrically driven air conditioners.2/

Although the water source heat pump compares favorably with virtually all energy sources, it exhibits an especially attractive economic character compared to electric resistance heating. It is proposed that the principal application studied be the 420 electric resistance forced air residential units in the "New Area."

Relative Benefits

The principal benefit to be expected from the water source heat pump in the proposed application is a reduction in energy consumption of 60% to 70% with a resultant reduction in load on the electric utility, especially during those peak usage periods when the utility has difficulty meeting demand. The water source heat pump has greater reliability and less maintenance than conventional air conditioners. Since water source heat pumps do not have outside fans and coils, they are also quieter than conventional air conditioners.

Proposed Program

It is proposed that the program be composed of the following five tasks:

Task I - Technical Study and Preliminary Design

This phase will establish the ground water availability , establish a "present case" annual load for the 420 unit complex and develop a projected load if all 420 units were converted to ground-water source heat pumps. This phase will study the single well concentric discharge concept as an alternative to a dual well system. A conceptual system design for a typical housing unit will be developed.

Task II - Definitive Design

This phase will develop the definitive design (drawings and specifications) for procurement of approximately six units within the 420 housing unit complex. This will include the design of the instrumentation system needed to quantify the performance of the six units.

Task III - Procurement and Construction

This phase will procure and construct (install) the six units including the instrumentation. The effect will consist of supporting Wright Patterson Air Force Base personnel in the procurement and management of the six installations.

Task IV - Startup and Initial Operation

This phase will consist of the startup and initial operation of each of the six units to insure that each unit is operating properly and that all instrumentation is functioning properly and that the data necessary to fully document the system operation is being obtained.

Task V - Long Term Operation and Performance Analysis

This phase will consist of the analysis and reporting of the performance data obtained on each of the six units, including comparisons to original performance predictions.

Schedule

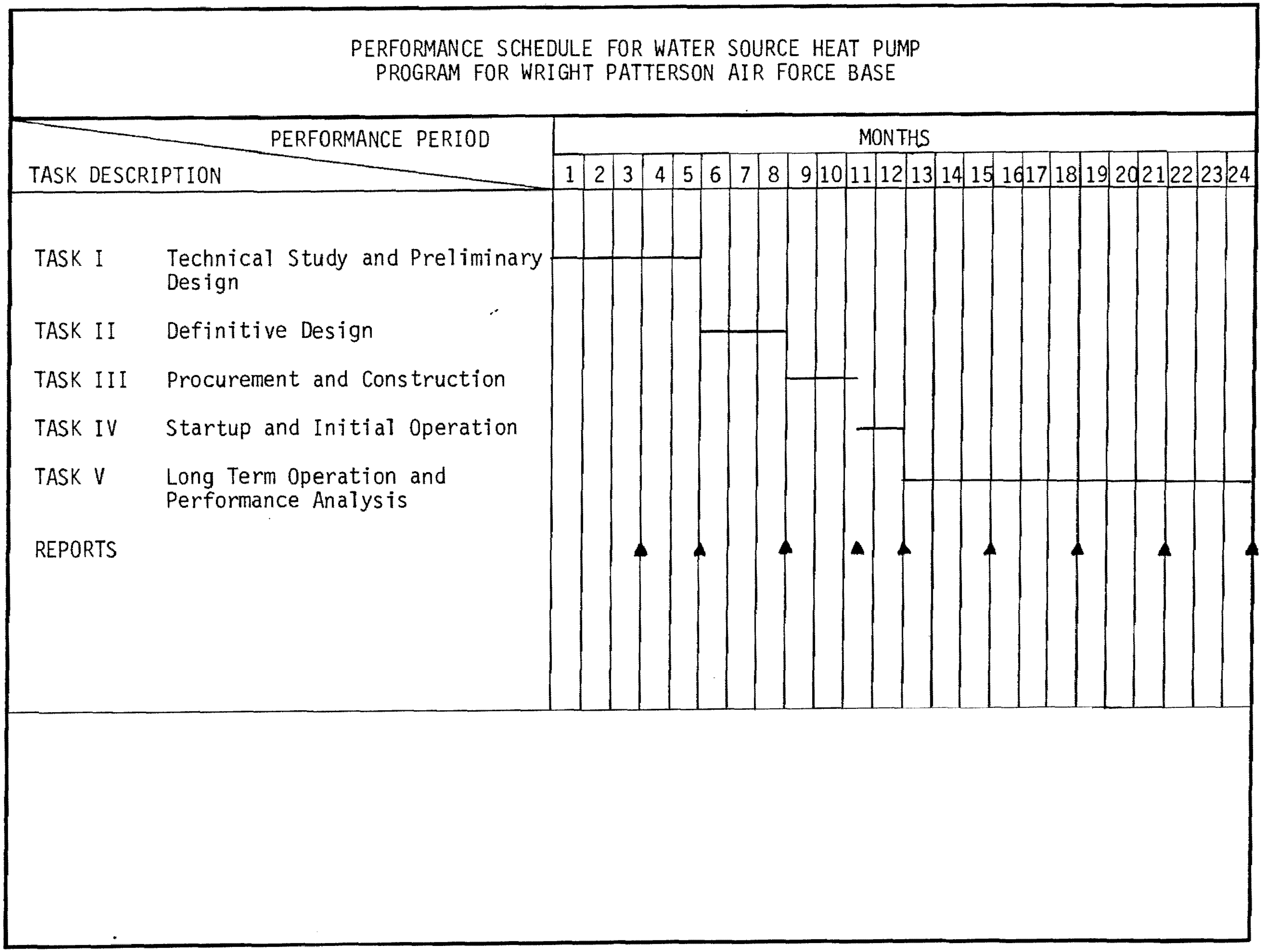
The bar chart shown in Figure 3 presents the estimated duration and timing of each phase.

Budget

The budget estimate outlined below is for a twenty-four (24) month period covering five (5) phases and includes the estimated installed costs for the six units.

Task I	$ 40,000
Task II	25,000
Task III	40,000
Task IV	10,000
Task V	20,000
Total Estimated Budget (24 months)	$135,000

Figure 3.


PERFORMANCE SCHEDULE FOR WATER SOURCE HEAT PUMP
PROGRAM FOR WRIGHT PATTERSON AIR FORCE BASE
PERFORMANCE PERIOD
TASK DESCRIPTION
MONTHS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
TASK I Technical Study and Preliminary Design
TASK II Definitive Design
TASK III Procurement and Construction
TASK IV Startup and Initial Operation
TASK V Long Term Operation and Performance Analysis
REPORTS

REFERENCES

1/ Average Temperature of Shallow Ground Water, Plate 30, Water Atlas.

2/ Akridge, J.M., Contract Presentation to Department of Energy Personnel on Department of Energy Contract EM-78-C-01-4216, Washington, D.C., September, 1978.

CONCENTRATING SOLAR THERMAL STEAM SYSTEM

For

UTILIZATION, TRAINING & EXPERIENCE

CONCENTRATING SOLAR THERMAL STEAM SYSTEM

Concept & Application

The solar thermal steam generation system would be comprised of:

- An array of concentrating solar collectors (The Collector Subsystem),
- A thermal storage system and heat transfer (The Thermal Storage Subsystem)
- A steam generator (The Steam Generation Subsystem)
- A control system (The Control Subsystem)

The energy collected by the concentrating solar collectors would be delivered to the thermal storage system for subsequent delivery to the steam generator where the saturated steam production would be admitted into the main steam line from a central system or would be used to produce hot water for delivery to a central hot water system.

Feedwater to the steam generator would be provided from an existing central fossil-fired boiler system and would return to the existing system as condensate; the total operational strategy for the solar steam system would be determined based on studies of the time-usage of steam from the central fossil fuel facility.

It is envisioned that a solar concentrating collector array of about 10,000 square feet would be utilized as the basis for the system design and the thermal storage and steam generation capacities would be defined based on solar insolation and weather data analyses, and on the most effective operational strategy relative to usage and fossil system modulation capability.

The thermal storage subsystem would be designed around a baseline sensible heat system such that alternate storage concepts could be employed after the solar system is operational. This would provide for overall flexibility in the future. For example, the baseline design could evolve around the use of an organic heat transfer fluid such as EXXON CALORIA HT-43, SHELL THERMAL 33, SUNOCO 21/25, or other similar fluids, and could be designed such that the later addition of solid media to the storage vessels would be possible, or, the fluid could be exchanged for organic compounds such as THERMINOL 55 or 66 should there be evolved attractive storage concepts using such materials. Further, should latent heat storage matrices be developed, they could be incorporated into the system at a later time.

The basic solar concentrator steam generation system concept is presented schematically in Figure 1.

Relative Benefits

The solar concentrating collector steam system would provide Wright-Patterson Air Force Base with a highly visible operational solar system which will integrate easily with an existing (or new) fossil fuel central thermal energy system and would provide for continuing training and experience on a solar facility such that when solar systems become competitive with traditional energy sources, a complete state of technological readiness will exist at Wright-Patterson Air Force Base.

This will assure a knowledgeable and confident approach in the transition to substantial energy displacement by solar facilities.

Schedule

The estimated total lapsed time required for the completion of an operational solar thermal steam system at Wright-Patterson Air Force Base is eighteen months-to-two years. The major elements visualized for the activity are:

- Analysis & Preliminary Design
- Definitive Design
- Procurement & Construction
- Initial Startup & Operation

The completion of the installation and the initial system operation would be followed by a one-to-two year operational monitoring program

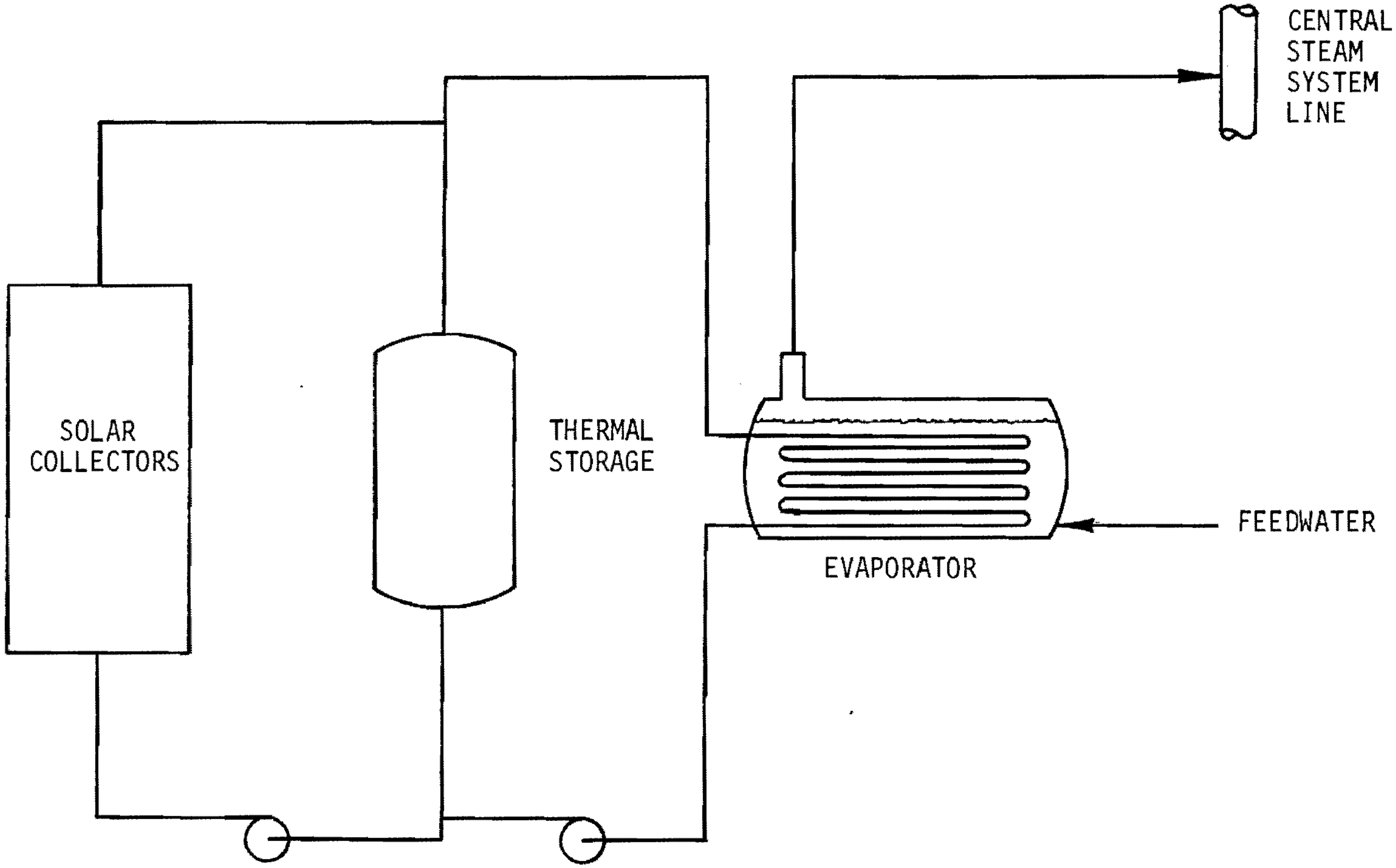


Figure 1. Schematic of Solar Steam Generation System.

where the actual performance would be carefully documented and compared to the performance predictions.

The estimated schedule for the required effort is presented in Figure 2.

Estimated Costs

The cost elements associated with each of the major activity elements are as follows: (estimated in 1978 dollars)

• Analysis & Preliminary Design	$ 90,000.00
• Definitive Design	105,000.00
• Procurement & Construction	600,000.00
• Initial Startup & Operation	45,000.00
• One-year Montoring Program	30,000.00
TOTAL ESTIMATED COST	$870,000.00

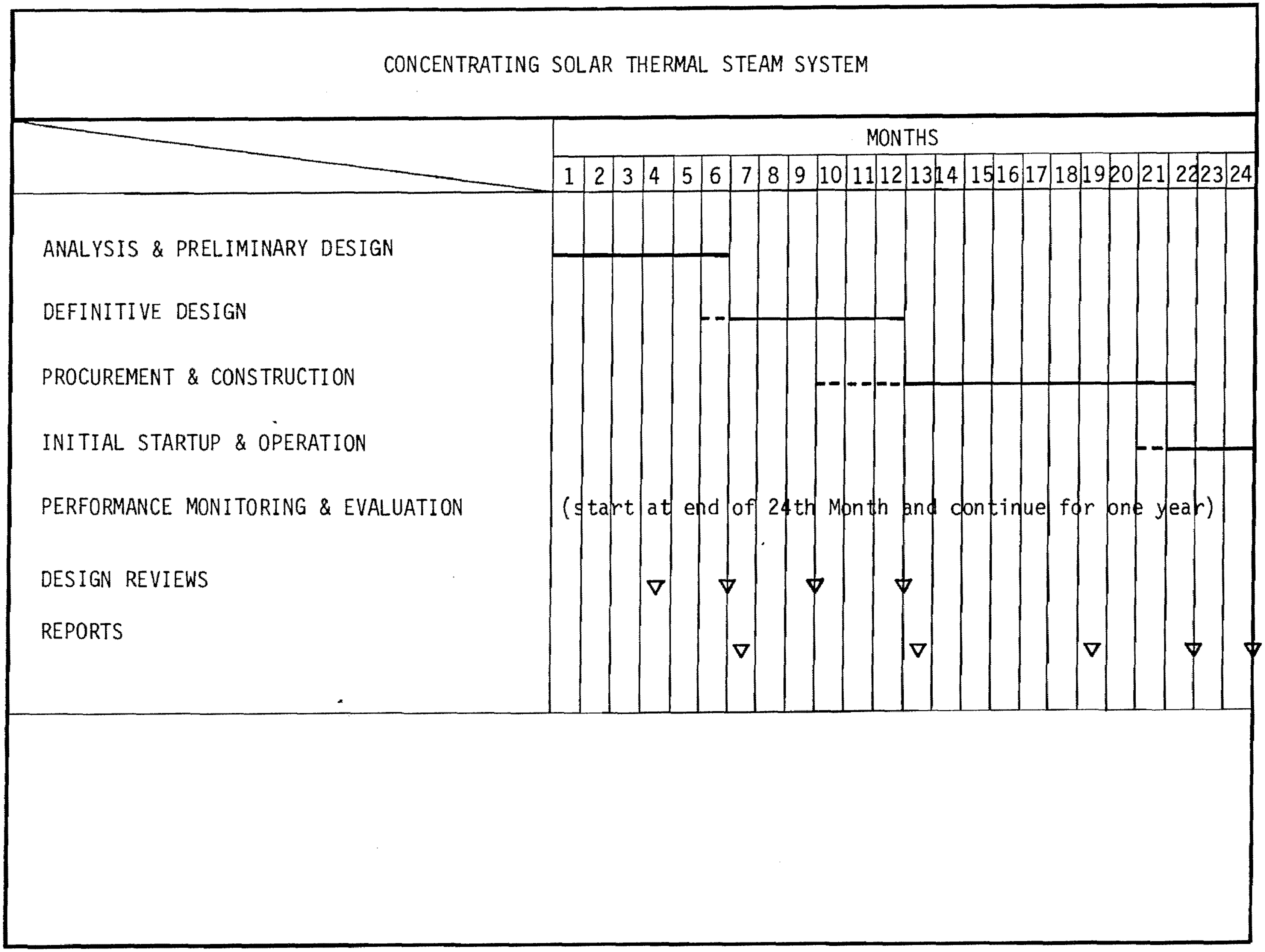


Figure 2. Solar Thermal Steam System Schedule.

THE USE OF A NUCLEAR REACTOR AS AN ENERGY SOURCE FOR A HOT WATER DISTRICT HEATING SYSTEM

THE USE OF A NUCLEAR REACTOR AS AN ENERGY SOURCE FOR A HOT WATER DISTRICT HEATING SYSTEM

PROBLEM STATEMENT

Wright-Patterson Air Force Base currently employs hot water distributed by a district heating system to heat some of the buildings on the base. The hot water is generated by conventional boilers which are fueled by high cost fuels including coal, gas, and oil. Although the majority of buildings on the base are heated by steam, future plans anticipate expansion of the hot water district heating system to supply domestic heating to those buildings.

The lack of economic security of supply of fossil fuels and the adverse impact on the environment of the combustion of such fuels represent two powerful arguments in favor of reducing the consumption of fossil fuels in domestic heating applications. To meet the demand for heat and reduce fossil fuel consumption, other forms of energy should be considered as heat sources in district heating systems.

PROPOSED CONCEPT

It is proposed that a small, low-cost nuclear reactor, designed exclusively for heating water, be studied as a source of energy for the existing hot water district heating system at Wright-Patterson AFB.

Ideally, such a reactor system would be used as a base load energy source with the existing boilers remaining operable as backup units to meet peak heating demand.

In determining the nuclear reactor to be used, consideration should be given to the feasibility of modifying the decommissioned Wright-Patterson research reactor for use as a hot water generator. A system which might prove more suitable for the application at Wright-Patterson, however, has been developed in Sweden under the acronym SECURE (Safe and Environmentally Clean Urban REactor).

CONCEPT DESCRIPTION

Historically, nuclear reactors have been used for propulsion in naval vessels, and on land to generate electric power. To be economical in these applications, reactors producing electric power have to operate at high temperatures and pressures and the risks associated with such operation precludes location of power reactors near areas of high density population which would be best served by district heating.

The SECURE district heating reactor is designed specifically for the production of low temperature hot water and it incorporates some operating principles which make the reactor inherently safe and suitable for location near areas of dense population. Since the SECURE reactor differs radically in design from conventional nuclear reactors, a description of its features follows: (Taken from Reference - "SECURE Nuclear Heat Reactors for District Heating" by Nilsson Lars.)

The reactor vessel with the reactor core is located in a large pool, which contains cold water mixed with boron. When this water enters the reactor core, the reactor will be shut down automatically by the boron absorbing the neutrons in the core and thus inhibiting the neutron chain reaction.

The reactor vessel itself has no pressure retaining function. There are permanent open connections without any valves or other obstacles between the reactor water inside the vessel and the pool water outside the vessel at the top and the bottom of the reactor vessel.

During normal operation, mixing of the cold highly borated pool water and the warm low-boron reactor water is prevented by a gas bubble in the hole at the top of the reactor vessel. The gas bubble is kept in place by the pressure drop across the core existing as a result of the reactor water circulation through the core. See FIG. 1.

Any reduction in the core coolant flow which could jeopardize the cooling of the core will cause a reduction in the pressure drop in the core. The gas bubble will then flow out of the reactor vessel and cold, high-boron water will flow into the core from the pool.

No mechanically driven control rods for fast shut down of the reactor are required. Reactor scram is initiated by simply stopping the reactor coolant pumps which in turn reduces the core coolant flow and the reactor is inherently shut down and cooled. See FIG. 2.

The cold high-boron water volume in the pool is sufficient for absorbing the decay heat of the reactor following a shut down for more than 24 hours, without the water temperature exceeding 212° F. See FIG. 3.

The large reactor pool is slightly pressurized and contained in a cylindrical prestressed concrete containment fitted with a concrete lid. The height of the containment is 75 ft. and the diameter 30-50 ft. depending on the thermal rating of the reactor.

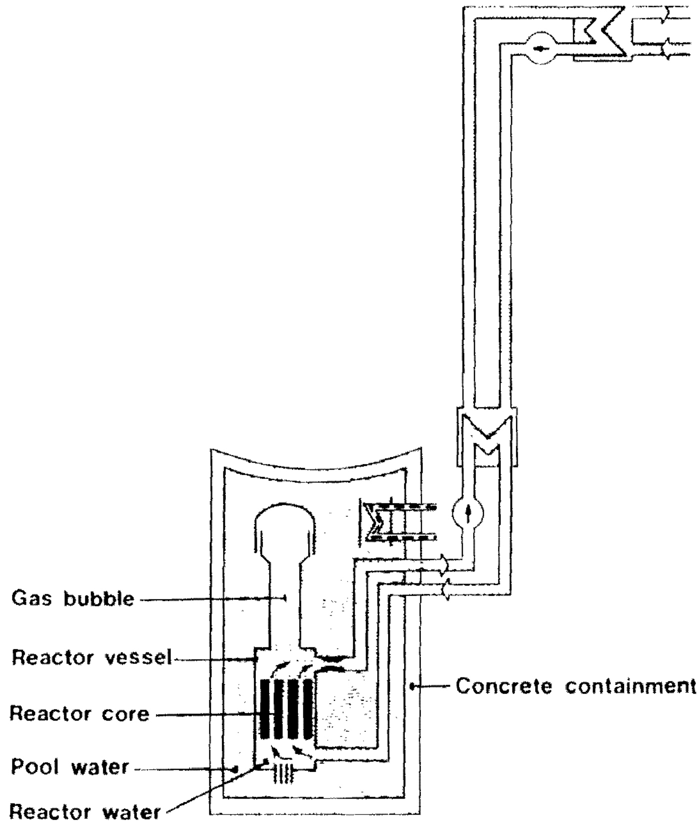


Fig 1 Normal operation and heat production to district heating grid

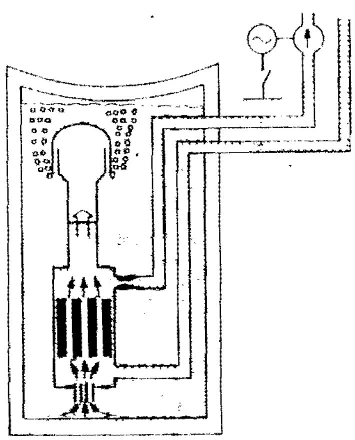


Fig 2 Inherent reactor shut down by reactor coolant pump trip

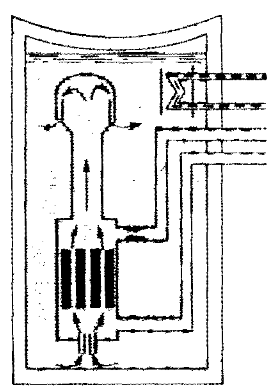


Fig 3 Inherent core cooling by natural circulation to pool water

The reactor core consist of fuel rods of uranium dioxide, similar to those used in conventional boiling water reactors. The difference is that the fuel rods are shorter and the power density at the rods is appreciably lower, resulting in very low fuels and cladding temperatures, thereby reducing the frequency of cladding defects as well as the release of fission products from the fuel to the reactor coolant in the event of their occurance.

The heat is produced in the reactor core and transferred to the reactor water which is heated from 200^{o} F to 250^{o} F on flowing through the core. The heat from this water is transferred to an intermediate circuit which - in turn - transfers it to the district heating grid. In the district heating system the water flow is heated from 160^{o} F to 210^{o} F.

The heat exchangers and pumps of the systems are all conventional equipment located outside the concrete vessel behind biological shields in the reactor service room, but are otherwise directly accessible for maintenance and service. See FIG. 5.

The plant can be adopted to above-ground siting, recessed siting or underground siting depending on local conditions.

EXPECTED BENEFITS

The inherently safe design of the SECURE reactor allows it to be sited in close proximity to areas of high population density, such as military installations. The lack of discharge of combustion by-products or rejected heat minimizes environmental impact. With a five - to - ten year fuel cycle, the SECURE reactor does not depend upon a constant supply of fuel, a property particularly desirable if the reactor is to be used at locations remote from fuel sources.

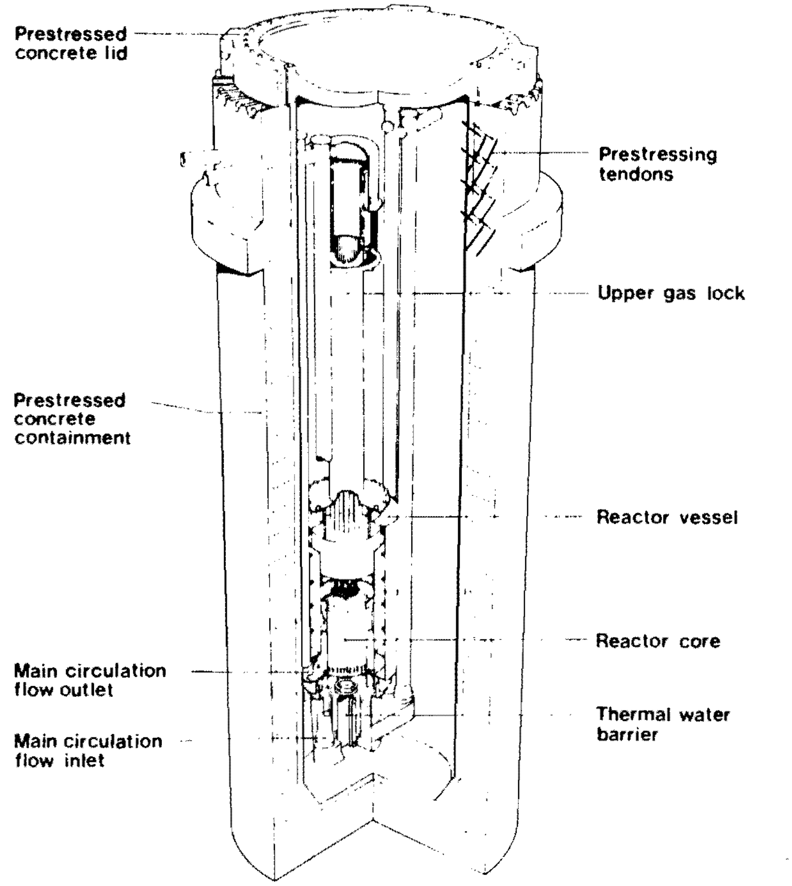


Fig 4 Reactor containment and reactor vessel

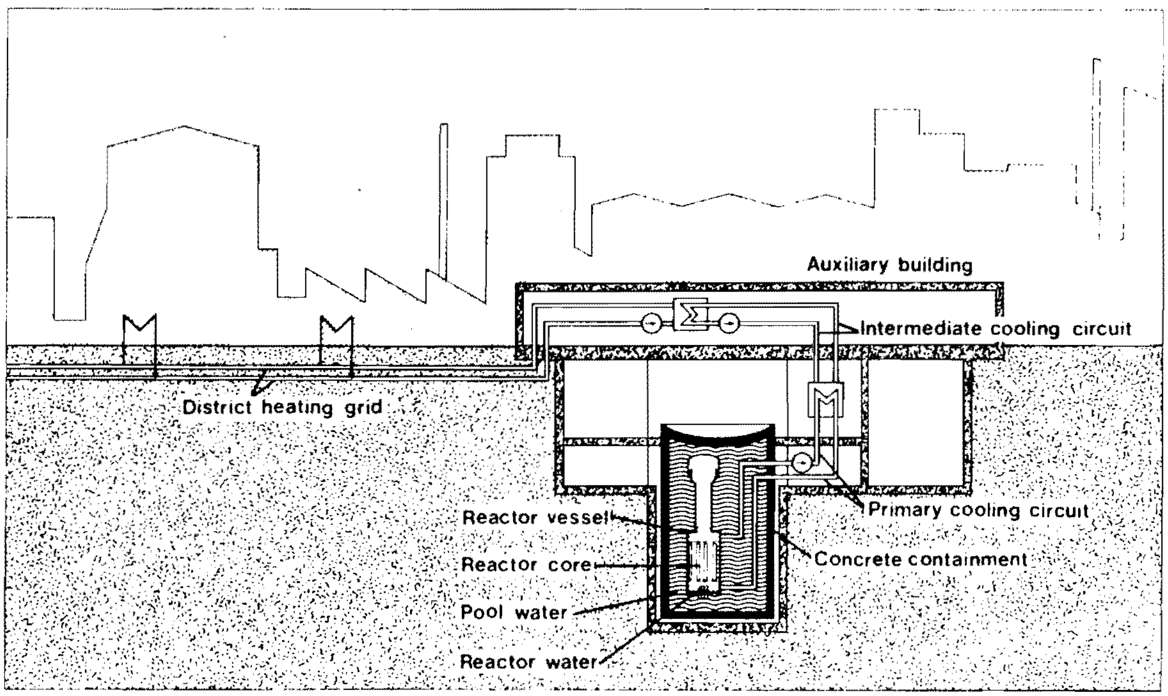


Fig 5 Station layout

Based upon the current Wright-Patterson AFB energy consumption rate, it is estimated that a SECURE reactor operating as a base-load unit could be used to supply 1.2 $x10^{12}$ BTU/YR in thermal energy to the base district heating system. According to the base fuel consumption pattern of 87% coal, 11% gas, and 2% oil, such an amount of nuclear energy would reduce base fuel requirements by 35000 TONS/YR coal, 132 MCF/YR gas, and 4385 BBL/YR of oil. As is the case with most nuclear reactors, the initial capital cost of installation would be high, but lower fuel and operating costs, considered over the system life-cycle, would make the SECURE reactor system economically attractive.

APPLICATIONS FOR BIOMASS ENERGY

APPLICATIONS FOR BIOMASS ENERGY

Wright-Patterson Air Force Base

Resource Assessment and Site Locations

A great deal of interest has been generated in recent years concerning the use of biomass as an alternate fuel to fossil fuels. Wood was the first fuel to be used for home heating in this country and as the nation developed, it became the basic fuel for industry. As coal and petroleum products became more available, the use of wood was curtailed to the point that it made an insignificant contribution to the nation's energy use. Wood and biomass are making a comeback and new technologies are emerging which could make this source of energy attractive for a military base. A military base offers certain distinct advantages which could simplify the use of biomass energy. Since a base has the attributes of a small city and is essentially self-governed, the institutional barriers which often hinder biomass applications could be dealt with more readily.

The first step to be taken when considering the use of biomass fuel involves the assessment of biomass resources available. To our knowledge, such an assessment has not been made on a large scale for Wright-Patterson Air Force Base. Before anymore serious consideration of new or retrofit wood or biomass systems for Wright-Patterson is taken, this important step must be carried out. There is little to be gained in considering the state-of-the-art in biomass burning equipment if a readily procured biomass fuel source is not available now and for the foreseeable future.

Several different categories of biomass should be considered in a study of the Wright-Patterson area including the following: on-base wood supplies, off-base wood supplies, crop residues, refuse derived fuels (RDF) and commodity biomass fuels. It must be emphasized that proximity to the base is a very important factor for the use of most of these alternatives since transportation over long distances can rapidly render them uncompetitive with conventional fuels. A preliminary study of the Wright-Patterson environs should probably consider no sources farther away than fifty miles. Each of the biomass categories shall now be considered.

On-base wood supplies at Wright-Patterson are currently limited to less than 1,000 acres according to recent estimates. This is probably not enough land to significantly impact the energy needs at an industrial-type energy supply on the base such as a large steam plant. There is some open land (closed airfields, etc.) that might be considered for use as an energy plantation, but it appears that the limited area could probably only supply enough wood on a sustained basis for on-base housing areas. This application should probably be looked at more closely.

Off-base sources of biomass within fifty miles of the base should next be considered. The amount of forest land available will determine the potential for fuel supply through proper forest management and harvesting operations. The presence of forest-related industries should be studied closely as well since these industries (sawmills, furniture factories, etc.) could supply waste wood for energy. Aid in this task could be obtained from the U.S. Forest Service, the Ohio State Forestry Commission, and various organizations of forest product industries.

Crop residues and refuse derived fuels are two other categories whose availability in the Wright-Patterson area should be considered. In the past, research has been done using such feedstocks as corn cobs, walnut shells, and peanut hulls as energy feedstocks. Many types of crop residues pose disposal problems for the farmer and these are good candidates for energy use. The large amount of farmland surrounding the base points to these possibilities.

It has been estimated that some 500 tons per week of solid waste is dealt with at Wright-Patterson and this source also represents a source of fuel that should be examined more closely. Admittedly there are real problems associated with the handling of refuse-derived fuel, but in the future, a steam or hot water plant which could use this fuel might be justified.

The last category of biomass to be considered is the use of densified biomass. Several firms are actively marketing wood pellets, refuse pellets, or combinations of the two which may hold promise as alternative fuels or fuel supplements for certain applications. Benefits include ease of handling and uniform heat content. Transport over larger distances to the base is feasible and there may be concerns which would be interested in doing business with Wright-Patterson on a long-term basis.

There are several specific areas on the base that could be considered for biomass usage. Since the west steam plant and the east high temperature water plant are both relying on coal as fuel, the possibility of using wood chips or pelletized biomass as a replacement fuel or a fuel supplement should be looked into for these plants. Since new equipment is being installed, it is apparently not feasible at this time to build new wood-fired boilers. In the future, this step could be considered if there is sufficient fuel supply in the Wright-Patterson area.

In addition to the large central energy systems on the base, there may be smaller applications where biomass conversion would make sense. The old SAC area might be one such application where perhaps a close coupled wood gasification system could be installed. There may be other areas away from the main base where "isolated" package boilers are in use which could be converted quite easily.

Indications are that most dormitory areas are handled adequately from central energy plants, but there may be some areas remaining where a wood stoker system of a commercial scale could be used to provide space heating.

Concept Description

Wood residue has been used as a fuel on a large scale by forest product industries for many years so the concept is not a new idea. The idea that is new is the use of wood residue and other biomass fuel by industrial plants which have no connection with wood products. For example, a municipal utility in Vermont is preparing to build a completely wood-fired steam power plant and a textile plant in Alabama is using steam generated by sawmill residue to provide energy for drying, dyeing, and other processing operations.

Direct combustion of bark and residue has been carried out by paper mills on a large scale for years. Field-erected boilers in size range up to 500,000 lb/hr of steam are in widespread use. It has only been fairly recently that interest has gained momentum in the small and mid-sized applications that would be appropriate for Air Force installations. In recent years, many new package boilers have been developed which are designed to burn wood residue. In addition, special burners are available which can burn dry (less than 15% moisture) wood in existing boilers.

Another field that is undergoing development is based on close coupled wood gasification systems. These systems are being worked on by at least ten different organizations in the United States and some are quite close to commercializing their product. A wood gasifier can be used to retrofit an existing gas/oil-fired boiler to burn wood waste, thereby utilizing capital equipment which is already in place. The widespread use of these gasifiers has the potential for opening up new industries to wood waste use.

There are some barriers to widespread gasifier use at the present and these include the need for more research and development work, the need for efficiency improvement, and the need for further work on automation. The Department of Energy and the Solar Energy Research Institute are tracking this technology, and, while funding for gasification projects is not widely available, there are definite possibilities for the future.

Benefit Analysis

The major benefits to be derived from the use of wood waste or other biomass is the use of a renewable resource which can assist the economy of a local area. If Wright-Patterson were to set up a biomass procurement program for industrial fuel, new jobs would be created and fuel purchases would have a multiplier effect on the local economy. The procurement of wood fuel would be (in the beginning at least) relatively insensitive to labor problems (such as the coal miners strike) and complete supply cutoff and irrational price increases (such as the Arab Oil Embargo).

In many areas of the country, wood energy has already been proven viable economically. Total tree chips or sawmill residue purchased for $12 per ton costs $1.33 per million Btu. This is the same price as coal which costs $35 per ton and #6 oil which costs 20¢ per gallon. Wood chips can be purchased in many areas of the country for $12 per ton, but there are very few small to medium users who can buy coal for $35 per ton and virtually no users who can buy oil for 20¢ per gallon. As the use of wood energy becomes universal, the price will have to rise, but it is expected that it will parallel the rise in coal prices and not even come close to the escalations of fuel oil, natural gas, or electricity.

Schedule and Cost Estimates

As mentioned previously, the major decision that must be made regarding the use of biomass energy at Wright-Patterson is the availability of the raw feedstock. If this decision is favorable, the conversion project could enter a conceptual design phase which would identify specific applications of wood and biomass energy to the base. The technology for direct burning of wood waste in boilers is well developed and packaged and field-erected wood boilers can be purchased readily. As large pieces of capital equipment, however, the purchase of some components of a wood energy system may require a long lead time. Capital costs for wood energy systems are generally much higher than for traditional oil/gas systems and are in the same ballpark as coal firing systems although expenses necessary to meet air pollution regulations can be much less. Recent data has shown that oil/gas-fired package boilers may cost from $5 to $8 per pound of steam per hour while package wood-fired boilers (including wood handling equipment) may cost 3 to 4 times that amount. Wood gasification systems for retrofit will cost $8 to $13 per pound of steam per hour and may thus offer a considerable capital savings when a gas/oil-fired boiler is available. Evidence collected on fluidized bed equipment available indicates that this technology for a wood system is quite expensive and may approach $30 per pound of steam per hour.

Operating costs of wood-fired systems will be rather high due to problems with handling solid fuel. These costs are expected to be about the same as for a coal-fired plant.

Thus, under present conditions, capital costs for wood-fired energy systems are relatively high compared to oil/gas systems, but fuel savings have demonstrated paybacks of less than 5 years in several situations (such as the textile mill in Alabama). When the useful life of a boiler plant is generally considered to be 20 to 30 years, this is a pretty good payback.

Other Air Force Biomass Applications

Due to the location of Wright-Patterson in a primarily agricultural area, the potential for wood energy use is perhaps not as great as certain other Air Force bases located throughout the country. A preliminary estimate turned up between 30 and 35 bases that should be investigated further for biomass use. The locations of most are not startling as they are in the northeast, Pacific northwest, and southeast. The southeast and northwest bases are probably in the best locations due to more moderate weather conditions enabling virtually year-round harvesting. There are several fringe areas that should also be investigated such as the northern half of California and Colorado.

References and Publications

Wood energy has received a good deal of attention in books and periodicals during the last several years. In order to keep abreast of new developments in the field, subscriptions to the following periodicals can be helpful:

Forest Industries
Pulp and Paper
Southern Pulp and Paper
Southern Lumberman
Environmental Science and Technology
Power
Chemical Engineering

In addition, there are pertinent publications coming out of the Department of Energy, the Environmental Protection Agency, and the Forest Products Research Society all the time.

The following bibliography lists some books and articles which may be informative about biomass energy.

Adler, Thomas J., Margaret Blakey, and Timothy Meyer. The Direct and Indirect Cost of Transporting Wood Chips to Supply a Wood-Fired Power Plant, Dartmouth College, 1978. An economic analysis of the procurement of whole tree chips. Available from:

Research Program on Technology
and Public Policy
ATTN: Barbara Ferraro
Thayer School of Engineering
Hanover, NH 03755

Babcock & Wilcox Company. Steam/Its Generation and Use, Babcock & Wilcox , 1978. General reference on the generation of steam, boiler design, and boiler operation. Available from:

Babcock & Wilcox Company
161 East 42nd Street
New York NY 10017
$25.00

Boobel, Richard W. Control of Particulate Emissions from Wood-Fired Boilers. (EPA 340/1-77-026), U.S. Environmental Protection Agency, 1978. Excellent reference on pollution regulations, abatement techniques, and wood combustion in general. Available from:

U.S. Technical Information Services
5285 Port Royal Road
Springfield, Virginia 22161

Corder, Stanley E., Ed. Wood and Bark Residues for Energy. Forest Research Laboratory, Oregon State University, February 1975. Discussion of various aspects of wood as a fuel. Available from:

Forestry Research Laboratory
School of Forestry
Oregon State University
Corvallis, Oregon 97331

Forest and Field Fuels Symposium Proceedings, October 12-13, 1977. Winnipeg, Canada. Biomass Energy Institute, 1978. Excellent articles on tree farming for fuel, pelletization, gasification, and liquefaction. Available from:

The Biomass Energy Institute, Inc.
P.O. Box 129
Postal Station C
Winnipeg, Canada R3M 3S7
$12.50

Forest Products Research Society. Energy and the Wood Products Industry. F.P.R.S. 1976. Papers on the combustion of wood. Available from:

F.P.R.S.
2801 Marshall Court
Madison, Wisconsin 53705

Forest Products Research Society. 1978 Energy Directory. F.P.R.S., November 1978. List of suppliers. Available November 1978 from:

F.P.R.S.
2801 Marshall Court
Madison, Wisconsin 53705

Forest Products Research Society. Wood Residues as an Energy Source. F.P.R.S. 1975. Detailed discussions of various aspects of wood combustion. Excellent reference. Available from:

F.P.R.S.
2801 Marshall Court
Madison, Wisconsin 53705

Goss, John R. "Food, Forest Waste = Low Btu Fuel," Agricultural Engineering p. 30-37, January 1978. An introduction and overview to gasification.

High, Colin J. and Susan E. Knight. Environmental Impact of Harvesting Noncommercial Wood for Energy: Research Problem. Dartmouth College, 1977. Available from:

Research Program on Technology
and Public Policy
ATTN: Barbara Ferraro
Thayer School of Engineering
Dartmouth College
Hanover, NH 03755

Junge, David C. Boilers Fired with Wood and Bark Residues. Forest Research Laboratory, Oregon State University, 1975. Best general book on burning wood for steam generation. Available from:

Forest Research Laboratory
School of Forestry
Oregon State University
Corvallis, Oregon 97331

Junge, Davis C. Investigation of the Rate of Combustion of Wood Residue Fuel. (RLO-2227-t22-2), September 27, 1977. Technical progress report on wood combustion techniques, mainly containing raw data on air fuel ratios and percent over and under fire air. Write to:

David C. Junge, Ph.D.
Office of Energy Research
and Development
Oregon State University
Corvallis, Oregon 97331

Love, Peter and Ralph Overend. Tree Power (Report ER78-1), Energy, Mines, and Resources of Canada, 1978. A general overview of all facets of wood for fuel. Available from:

Western Forest Products Lab
6620 N.W. Marine Drive
Vancouver, B.C., Canada V6T 1X2

Mingle, J.G. and R.W. Boubel. "Proximate Analysis of Some Western Wood and Bark," Wood Science VI:1, July 1968, p. 29-36. Techniques and procedures for testing wood fuel.

Reed, Tom and Becky Bryant. Densified Biomass: A New Form of Solid Fuel. SERI, 1975. Information on pelletization. Available from:

SERI
1536 Cole Blvd.
Golden, Colorado 80401

PHOTOVOLTAIC CONCENTRATOR FOR REMOTE SITE APPLICATIONS

PHOTOVOLTAIC CONCENTRATOR FOR REMOTE SITE APPLICATIONS

Building Location and Description

Air Force mission requirements dictate the operation of numerous remote radar and communication sites. Electrical power requirements in these remote sites are typically met with storage batteries which are replaced periodically or by diesel engines. Many of these sites require power levels less than 5 kW and are excellent candidates for operation by solar photovoltaic devices. The remote nature of these sites makes servicing with fuel or charged batteries expensive thus justifying replacement of power sources with photovoltaic devices.

Concept Description

The proposed photovoltaic power module will utilize a five meter diameter, paraboloidal, two-axis tracking collector with a photovoltaic array approximately one-half square meter in area. Peak output power from the module will be 1.2 kWe at an insolation of 1 kW/M^2. Multiple collectors can be installed in applications requiring a higher power level. A battery storage unit will buffer the differences between the photovoltaic system output and the load demand. A d.c. to a.c. converter will be provided where necessary; equipment requiring d.c. can be operated directly from the array.

Use of the concentrator will reduce the area of the photovoltaic array, thus reducing the solar cell costs. This reduction in cell costs will be partially offset by cost of the concentrator, solar tracking system and array cooling system which will be required. However, a net reduction in system cost is projected over a flat plate array. The photovoltaic array will be positioned perpendicular to the axis of the paraboloid and situated off the focal point to spread the energy over the array surface. Concentration ratio will be approximately 40 suns with an array area of approximately 0.5 square meters.

The paraboloidal solar concentrator will be similar to tracking paraboloidal communication antennas which are widely used for satellite applications. Such antennas are manufactured in quantities of 100's and mass manufacturing techniques are being developed due to the rapid growth in the satellite communications business. Scientific Atlanta, a leader in this field, has developed a method for die stamping pedals which bolt together in the field to form an accurate 5 meter diameter paraboloidal dish. Utilization of reflecting foils makes this dish a concentrator of short wave radiation, making it a solar energy concentrator with a concentration ratio up to 500:1.

Active cooling of the array will be necessary to maintain solar cell temperatures below 70 °C, their maximum operating temperature. Cooling of a 40x concentrator becomes particularly difficult due to the pumping requirements which can consume a significant portion of the system power. Cooling of the array will be accomplished using a freon vaporizer/condensation cycle which provides for efficient heat transfer under widely varying ambient conditions. The freon system appears to offer the maximum cost-benefit opportunity and would significantly enhance the application flexibility and provide the opportunity for factory precharging of systems. The reject heat from the array will be useful in some applications to maintain proper battery temperature.

A battery charger/voltage regulator will be required to function as an interface between the solar cells and the storage batteries. This device ideally presents a proper load impedance to the solar cells to allow them to operate at or near their maximum power point (i.e., it optimizes the match between the collector system and battery I-V characteristics). At its output, the charger must present the proper charging voltage to the batteries to allow them to charge fully at the proper rate and without exceeding their full charge capability.

The d.c. to a.c. converter will utilize high current fast switching power thyristors and integrated circuits which yield low switching losses and thus high conversion efficiencies. Excellent dynamic voltage regulation is provided by utilizing pulse width modulation of the chopped waveform.

The Department of Energy is currently soliciting proposals for the "Design and Construction of Advanced Design 10 kW Power Conditioning Units For Photovoltaic Power Systems". This program should provide improved voltage regulators and d.c. to a.c. converters for the proposed remote photovoltaic power module.

The solar cell array will consist of closely spaced cells interconnected in series-parallel fashion to provide the required d.c. voltage and current. Special attention must be focused on the uniformity of the solar intensity across the array surface. Concentric subarrays may be advantageous to compensate for any nonuniformity. A major concern with the array will be to mount cells on the heat rejection plate in a manner so as to minimize the thermal resistance.

Benefits Analysis

Providing power to remote Air Force sites requires the installation of expensive power lines or the periodic replacement of storage batteries or diesel fuel, thus representing a high labor cost as well as battery replacement cost. The high cost of power for these remote sites suggests the use of photovoltaic devices for power generation. The relatively high current cost of photovoltaic devices ($10-$15/watt) limits their application in competition with commercial power. However, for remote sites the comparison is much more attractive and as photovoltaic prices continue to fall their use for remote power applications is expected to increase drastically.

Selection of a specific remote site by the Air Force will be followed by a detailed analysis of the equipment energy demand and of available solar energy. This analysis will enable a decision to be made regarding the battery storage and array size necessary to provide year-round site power.

Sdhedule and Cost Estimate

The proposed program to design, build and install a photovoltaic concentrator at a remote Air Force site will be approached in two phases. Phase I will involve the identification of an appropriate site, detailed analysis of the load demand and available solar energy, and design of the photovoltaic power module. This initial phase is expected to cover approximately six months and would involve a level of effort of approximately 1-1.5 man-years. A task of the Phase I effort will be to generate a detailed cost estimate and program plan for the Phase II construction effort.

Phase II will probably require 12-18 months to fabricate and install the power module. Materials, supplies and equipment for this initial unit should be on the order of $20-30K, assuming only one concentrator. The level of effort on Phase II is difficult to project, but three man-years appears reasonable for budgeting purposes.

ENERGY EFFICIENT ELECTRONIC BALLASTS FOR FLOURESCENT LIGHTING

ENERGY EFFICIENT ELECTRONIC BALLASTS FOR FLUORESCENT LIGHTING

Building Location and Description

It is proposed that this technology be demonstrated in an office-type facility with perimeter area with natural light as well as core area with no natural light. The building lighting must be primarily 40-watt fluorescent. The lighting levels should be moderatly high - 75 to 100 footcandles.

The building that appears to meet these qualifications is Building No. 125. It is assumed that this facility utilizes fluorescent lighting systems with conventional magnetic core ballasts. It is understood that the building is supplied with electric power purchased from the Dayton Power and Light Company. The electric power is delivered to the building at standard secondary voltages (208Y/120 or 480Y/277) and frequency (60 H_z).

Concept Description

Electronic ballasts for electric discharge lighting (fluorescent, HID) offer good potential for energy conservation. The typical equipment presently used is the magnetic core ballast. This standard ballast is basically a wire transformer with related components to boost line current and control current to gas-filled lamps. The electronic ballast uses solid state components to accomplish this purpose. However, the electronic ballast offers several benefits that are not possible with the magnetic core ballast.

At the present time, electronic ballast equipment is in the development stage by one or more firms. At present, this equipment is specifically applicable to 40-watt fluorescent lamp systems. Under a contract from the U.S. Department of Energy, this technology is being demonstrated at the Pacific Gas & Electric Company headquarters building in San Francisco.

The advantages of electronic ballasts include the following.

- Power Savings - The electronic ballast operating frequency is in the range of 25 to 35 KH_z. This high frequency results in a 20% light efficiency improvement. Also, solid state devices offer better electrical efficiency than the components used in the standard magnetic core ballasts.

- Additional Power Savings Through Dimming - The electronic ballast can be dimmed without serious efficiency loss. This dimming capability allows for reduction in artificial light to take advantage of available natural light. Almost infinite control of the lighting system permits better matching of light output to work task. The present lighting design method is to initially install too much lighting to assure a design "maintained lighting level" as the lighting system detenates. The dimming capability will eliminate this waste.

- AC or DC Power - The electronic ballast can be designed to operate from either alternating or direct current power. This allows for fixtures to be utilized for emergency lighting and can be used where the power supply is from photovoltaic solar systems

- Retrofit - Electronic ballasts can be installed in present lighting system.

Other advantages include:

- No flicker
- No detectable sound
- Reduced weight
- Less heat

We propose the following research work.

Task I - Wright-Patterson Demonstration

A demonstration project at Wright-Patterson to evaluate electronic ballasts specifically at this facility. A typical air force office-type facility should be selected. This demonstration project will concern itself with:

- Energy savings in perimeter office areas where automatic dimming permits the effective use of natural light.
- Energy savings in the absence of natural light.
- Electromagnetic interference.
  Previous D.O.E. reports have shown that EMI with electronic ballasts exceeds that for magnetic core ballast in the RF range. This will be evaluated with the above demonstration as well as off-site investigation. The results will be correlated with FCC regulations and recommendations will be given.

Task II - Electronic Ballast with Photovoltaic Solar Power

An area will be chosen for lighting "self-sufficiency" evaluation. The lighting system in this area will be powered by a combination photovoltaic DC system with battery (or other) back-up. With photovoltaics, the power required is 40% - 50% less with electronic ballasts than with inverters and standard ballasts.

The Department of Energy has several projects underway to demonstrate photovoltaic solar systems. The application of electronic ballasts for lighting utilizing D.C. power from photovoltaic systems should be researched. A project at Wright-Patterson demonstrating this technology and jointly funded by D.O.E. and DOD is suggested.

Benefit Analysis

Potential savings with electronic ballasts are from 20% to 40% of electric discharge lighting energy exclusive of photovoltaic applications. The electrical energy consumption at Wright-Patterson Air Force Base was 2.93 X 10^6 KWH in FY '78. Of this total, it is estimated that 20% or 58.7 X 10^6 KWH was consumed by lighting applicable to electronic ballasts. Therefore, the annual savings potential at Wright-Patterson might be:

$$58.7 \times 10^6 \text{ KWH} \times 30\% \text{ average savings} = 17.6 \times 10^6 \text{ KWH annually}$$

At an average cost of 3.5¢ per KWH, this cost savings amounts to $616,000 annually.

Due to improved electrical characteristics, the electronic ballast will operate cooler, have a longer life and be more reliable than the standard ballast. The electronic ballast will lend itself more to self sufficiency as it can be powered by DC or AC suppliers.

This research project is estimated to cost $50,000 exclusive of photovoltaic equipment. It is suggested that a photovoltaic array be a separate funding item and used as a research energy source for this project as well as others. This project funding level will support:

- Data collection and evaluation
- System design for demonstration
- Purchase and installation of demonstration equipment - $30,000
- Purchase and installation of instruments - $20,000
- System monitoring
- Data documentation and reporting

It is estimated that this level of funding will permit field demonstration of 20 KW of lighting with electronic ballasts.

Schedule and Cost Estimates

The project is estimated to require 18 months duration for completion. A task schedule is as follows:

Task I - 18 months total

Investigation of data - 1 month

Design - 1 month

Equipment and instrument purchase, installation - 2 months

Demonstration and evaluation - 12 months

Data evaluation and reporting - 2 months

Task II - 12 months

Site selection and design - 2 months

Installation/interface (with instrumentation) - 2 months

Demonstration - 6 months

Data evaluation and reporting - 2 months

References

Phase II Report on Energy Efficient Electronic Ballasts for a Two 40 Watt Fluorescent Lamp System, LBL-7871, Lawrence Berkeley Laboratory, Energy and Environment Division, University of California,Berkeley, July 1978.

Note: This report prepared for the U.S. Department of Energy under Contract No. W-7405-ENG-48

A PROPOSAL FOR COMPREHENSIVE, SITE SPECIFIC ENERGY PLANNING AT WRIGHT-PATTERSON AIR FORCE BASE

A PROPOSAL FOR COMPREHENSIVE, SITE SPECIFIC ENERGY PLANNING AT WRIGHT-PATTERSON AIR FORCE BASE

SCOPE

The proposed project will involve all existing structures and planned facilities which are contemplated in the short and long term missions of Wright-Patterson Air Force Base.

CONCEPT

A significant amount of attention has been focused on the aggregate amount of energy used by communities due to the manner in which they are planned and constructed on an incremental basis. Currently, the Department of Energy is exploring ways to reduce community energy consumption through community planning and the integration of community energy systems.

INTEGRATED COMMUNITY ENERGY SYSTEMS

Integrated Community Energy Systems are a comprehensive approach to energy conservation involving an entire community. Incorporating ICES into our society involves innovative technology, energy conserving community design and unique financial and regulatory mechanisms. Partial or complete integration of a community's energy supply and demand system are possible. The degree to which the concept is applied depends on various economic, social, and environmental criteria as well as the energy conservation goals of the community. Some of the specific goals of an ICES are: to reduce the demand on scarce fuels, to lower and stabilize energy costs to consumers and to minimize unwanted effects such as noise and air pollution.

ICES conserve energy by making appropriate use of each unit of fuel. This is done by supplying energy in steps that are matched to end-use with a decrease in quality with each step. For example, coal is used to produce high pressure steam that generates electricity (at a 30% efficiency), then the lower pressure steam exhausted from the electric generating process can be used to produce hot water to provide space heating and/or cooling and domestic hot water. If the same initial energy can be used by more than one process there is an increase in overall efficiency.

There are four components to an ICES - Resource, Central plant, Distribution and Storage, and End-Use systems. The resource system supplies primary fuel. It is desirable to use the most abundant, least polluting fuel in the local area. The central plant provides the initial conversion of high quality energy such as electricity. The distribution and storage system takes the products and wastes of the central plant and delivers them to the appropriate end use or storage system.

Community design is an important element of ICES. By siting employment opportunities near residences, allowing growth along existing transportation lines and considering energy usage in land use planning, a great deal of energy can be saved. The result is lower initial and operating costs of energy systems to the consumer.

ICES is a new idea, and some changes in lifestyle will be necessary to incorporate them. These may include walking to work, allowing slight temperature variations in buildings, and energy use awareness on the part of the consumer.

Energy supply must be matched with community growth and management of development is necessary for a successful ICES.

Some of the ICES concepts being evaluated are:

MIUS

Modular Integrated Utility Systems are on-site combined package plants that provide communities of limited size with electricity, heating, air conditioning, water, and liquid and solid waste treatment and disposal. They are modular in that they are located near users and are designed to be in phase with the demands of the community. Resource requirements of one service are met by utilizing the waste of another where possible. Electric generation is placed near consumers in order to utilize waste heat. Solid and liquid waste treatment systems are also integrated with the total energy system.

The primary goals of MIUS are to conserve natural resources, reduce energy consumption, minimize adverse environmental impact, provide utilities in phase with the demands of cummunity, eliminate impact of local restrictions on waste treatment and reduces the total cost to the nation for utilities.

Some technologies used to incorporate MIUS are internal combustion engines, gas turbines, solar energy, heat pumps, pyrolysis and biological treatment of waste

TIES

In a Total Integrated Energy System (TIES), the electric power output of a local power generation plant goes into the utility company distribution grid rather than to the user. The user is served with electric power from the grid and receives heating and cooling media from the local power plant's waste heat. The utility grid provides a large source-sink for electric energy. The TIES plant is controlled by thermal demand, without auxiliary energy requirements at individual buildings. Sizing to the plant is dependent on economics and waste heat demand.

Some conditions that must be met to incorporate a TIES are:

- The plant should be utility company operated, but not necessarily owned.
- The TIES electric capacity should not exceed 20% of a utility company's minimum demand.
- The utility company should pay a monthly demand charge as well as a per KWH charge to the TIES plant owner since the maximum output of the TIES plant is available to the utility upon demand.

COGENERATION

Cogeneration systems combine the production of electric power with thermal energy needs. This provides a higher overall cycle efficiency than generation of electricity and heat separately since the same energy source is used to provide more than one service. German studies indicate that cogeneration is now economical for populations of 40,000 or greater. The cogeneration plant must be sized to the community for effective energy use.

PASSIVE APPROACHES TO COMMUNITY DESIGN

The energy use in a community is a function of the community layout. Location of residential areas with respect to industrial and commercial areas directly affect transportation energy consumption. Ideally, it is best to have a mix of these areas in one location such that everyone could walk or bicycle to work and recreational facilities; however, this is not possible in most cases in todays society due to environmental effects such as noise and air pollution from industries. A compromise is to provide accessible low energy transportation routes and vehicles from one area to the other. Examples of these are busses, van and car pools, bicycle and pedestrial pathways, and mass transit systems.

Building orientation and design affect heating and cooling energy consumption. Some building designs such as square 1 story unit require less energy per unit floor area to heat and cool than do rectangular 2 story units. Using proper levels of insulation further decreases the heating and cooling load. Attached units require less energy than single family dwellings... There are also many design features that will allow you to use solar energy for heating and cooling without the use of mechanical equipment. These are referred to as passive designs and include atriums, south facing windows, shading devices, solar chimneys and window heaters, earth berming, underground building and others. Passive designs can reduce energy consumption in buildings by fifty percent or more.

PASSIVE DESIGN OPTIONS

Passive design means utilizing various elements of the local natural environment to reduce the external energy needs of the community. These generally include the consideration of the sun, wind, and earth to minimize use of other energy sources. By incorporating passive design ideas into facilities and site design, smaller thermal and electric loads will be incurred. This results in smaller community energy system equipment size and therefore a lower total system cost. Some passive ideas that are applicable to the site include earth berming and underground building, greenhouses, atriums, south facing windows, various heat collection devices (trombe walls, drum walls, window collectors, etc.) and ground ducted cooling as well as combinations of these. Most of these add only 1 to 5% to the cost of a conventional building, and are applicable to residential, commercial, and industrial buildings. Passive designs require little life-style changes and, in fact, are esthetically pleasing. Residents may need to wear appropriate clothing during temperature extremes.

Passive designs are not only limited to individual buildings. The whole community can be arranged to take advantage of natural wind flow for ventilation, and maximum solar access to heating, cooling and lighting. Lakes that are on the site could be used as a heat source/sink for the community energy system.

Radial design of the community will use less energy than having all facilities at one end, and all residents at the other. This could improve community services (especially Police and Fire) at the same time and minimize distance travelled by the community residents. Cluster design should also be incorporated here. If a central community energy system is used, it should also be centrally located.

TRANSPORTATION

Clusters, rather than long streets are more efficient in energy use as more homes are put on the same street. This also minimizes embeded energy costs by reducing the amount of asphalt or cement used. Furthermore, it has been found that pavement adds to the thermal load of the surrounding buildings so by minimizing pavement, smaller loads are incurred. By supplying bicycle and pedestrian paths as well as van pools to residents, they will use these as alternatives to automobiles in getting to work, shopping and recreation areas.

RESIDENTIAL PARTICIPATION OPTIONS AND LIFESTYLE CHANGES

Community participation is the real key to energy conservation. Much of what is writtnen about community systems state that major lifestyle changes are unacceptable as energy conservation options, but by including community involvement in the energy conservation plan, there is a greater potential to save more energy, and for the residents to have a more satisfying existence. If people feel that they are an integral part of the plan, more energy will be conserved. This is easier to do on the small scale community level than in a large city. If you show people that they can save money through energy conservation measures, they will incorporate these measures without doubt. Some specific ideas to consider are:

An energy conservation committee, made up of residents, to oversee energy consumption patterns within the community. They would also educate the communtiy about peak loading, heating and cooling their homes, recycling waste, modes of transportation and other energy intensive activities.

Another option is that residents could be asked to separate aluminum, glass, and other garbage. Aluminum and glass can be collected and sent to a nearby recycling station at a profit to the community that offsets utility costs (this could be minimal at today's recycling rates) and other garbage could be processed and used for heat generation. Residential garbage containers for each material to be recycled could be provided at each residence. Collection could be contracted or community owned truck.

BENEFIT ANALYSIS

The building composition and normal activities of military bases are essentially the same as those of private sector communities. It is reasonable to assume that the energy conservation benefits available to communities through planning, site analysis and incorporation of passive design elements into building construction will also be available to military base communities.

The primary benefit to be derived from the planning effort will be an orderly progression of phased construction which will move the base to a desired lower level of energy consumption. This will be accomplished by setting energy budgets for new projects and evaluating building obsolescence and renovation in light of energy needs.

SCHEDULE

The technology required for implementation of a comprehensive energy plan is essentially available. Refinements of the application of passive design concepts and technical feasibility studies of various Integrated Community Energy Systems are currently being sponsored by the Department of Energy.

This emerging technical base will be available for near term planning and will most likely be demonstrated before most of the long range needs at Wright-Patterson are realized. It is, of course, a distinct possibility that some of the concepts for ICES or planned community growth for energy goals could be demonstrated at the Wright-Patterson Facility.

TOTAL ENERGY SYSTEM - COGENERATION

TOTAL ENERGY SYSTEM - COGENERATION

Introduction

The Wright-Patterson Base can be characterized as a high density energy use area with respect to both electrical and thermal energy, as is true of all large military bases. This characterization indicates that the Wright-Patterson facility is a strong candidate for implementation of a cogeneration system in which electrical power is produced in a Rankine steam cycle plant and thermal energy is extracted in a bottoming cycle for use in the base district heating system. Such a cogeneration system would provide a much greater measure of energy self-sufficiency, limited only by the amount of on-site fuel storage which is feasible. In addition, the efficiency of electrical energy production would be greatly increased, thus lowering energy costs and conserving fuel resources.

Concept Description

At present, electrical energy for WPAFB is purchased from a public utility, Dayton Power and Light. The base electrical load consists primarily of office, commercial, and residential demands associated with base operations (primarily adiminstration and research) with a small amount of industrial demand associated with aircraft maintenance and research test facilities.

The thermal energy demand is accounted for in large part by the district heating system, which is supplied by several central heating plants on the base which use coal for fuel.

A cogeneration system for the WPAFB would consist of a single or several central steam electric generating stations constructed on the base which would use a variable extraction turbine system (Figure 1). This type of system would incorporate a condenser to allow operation of the electric generating station independent of the thermal energy demand, with the degree of efficiency of electric energy production dependent on the concurrent thermal energy demand.

The approximate size of a total energy cogeneration system for WPAFB would be 75 to 100 MWe, based on the existing peak thermal demand. Such a system would produce an excess of electric power during times of high thermal demand, since current average electric demand is only 35 MWe during this period. Therefore, the systems would require the dumping of excess electric power to the existing utility grid outside the boundaries of the base. Such an arrangement could prove beneficial to Dayton Power and Light, since the utility could purchase power from the cogenerating system at a lower cost than they can produce it at their conventional generating plants. The disadvantage of the sale of electric power would be the fact that the power available for sale to the utility would fluctuate according to power demand on the base. These fluctuations could possibly be dumped through use of an electrical energy storage system, such as a battery storage bank. Current energy consumption patterns at WPAFB indicate that, during the summer months, the electric demand may equal or slightly exceed the thermal demand. Assuming a cogeneration system is designed for peak thermal demand, the system would have to reject a majority of thermal heat in the condenser during the summer, but would still operate more efficiently than a conventional Rankine cycle plant. An alternate approach for the cogeneration concept would be to levelize thermal demand by conversion of existing electric demand to thermal demand, e.g., replacement of electric chillers with absorption chillers.

Implementation of a cogeneration system at WPAFB is most probably a long range goal. At present, a substantial investment has been made in new and renovated central heating plants, and to consider near-term retirement of these costly facilities would not be economically attractive. However, over the useful life of these plants, the required modifications for implementation of a cogeneration system could be integrated into the base energy system. These modifications would include:

- Replace electric and thermal energy end users to level the demand on an annual cycle.

- Negotiate an electric utility interface agreement with the local utility, addressing both possible capital procurement arrangements for plant construction and sale of excess power to the utility.
- Design the central generating plant boiler system for use with the optimum fuel system determined to be available.

Potential Benefits

The primary benefit of a total energy cogeneration system is the improved efficiency of fuel-to-electric energy conversion. Conservatively, a cogeneration system can reduce the heat rate (Btu/kwh) of a conventional Rankine cycle steam generating station by 50% to 60%, assuming total utilization of system thermal energy capacity. This improved efficiency translates into a potential energy cost savings at the Wright-Patterson base of $4 to $5 million annually, based on current electric energy consumption. Additional benefits which can be realized include:

- Energy self-sufficiency - a military base can maintain a total energy supply system within its boundaries, limited only by fuel storage at the site.
- Lower Electrical Distribution Losses - an on-site generating station is located in close proximity to the base electrical distribution system, reducing transmission line losses.
- Flexibility of Fuel Supply - a new cogeneration system can be designed to utilize multiple sources of fuel, e.g., a fluidized bed combustion unit able to burn coal, biomass and/or refuse derived fuel.
- Use of Public Utility Capital Resources - a possible agreement for construction of a cogeneration system with the local electric utility could include use of capital acquisition methods routinely used by the utility to generate construction capital in exchange for sale of electric power to the utility.

Schedule and Cost Estimates

Construction of a cogeneration system at WPAFB is probably not economically feasible in the near future due to the remaining time needed to retire the new district heating system thermal plants. However, the planning process for any new electric generating station is of necessity a multi-year proposition. Therefore, long-range energy planning at WPAFB should address a cogeneration system and the planning period should be used to evaluate the following:

- Means of optimizing the electric-to-thermal demand with respect to cogeneration,
- Negotiating an agreement with the local utility for both plant construction and electric power sale,
- Assessment of potential fuel sources, addressing supply, cost and storage.
- Assessment of an electric energy storage system for leveling electric demand.

Estimates of future costs for a cogeneration system would be addressed in the long-range planning mode. Present costs for a 100 MWe coal-fired generating station are on the order of $100 to $150 million, and herein lies the major drawback to the cogeneration system. However, the possible raising of capital through the local utility is an attractive proposition.

The investment incentive for a cogeneration system will be reduced energy costs and revenue from electric power sales. An additional, but more intangible incentive is the greater degree of energy self-sufficiency which a cogeneration system would provide.

CONCENTRATING SOLAR LIGHTING SYSTEMS

CONCENTRATING SOLAR LIGHTING SYSTEMS

Building Location and Description

This solar powered lighting system can be used on large office buildings and remote areas such as missile silos and bunkers. It can augment artificial illumination from fluorescent and incandescent sources.

Concept Description

The technology involved in this lighting system is based on optical enhancement of the age-old light source, the glass window. It uses a tracking-type concentrating collector and lens system to concentrate the sunlight and beam it down into the space to be illumianted. This allows for a small opening into the structure, higher security, and lower heat loss or gain. This system can supply large amounts of light to different spaces through a relatively small light shaft. Experiments have already been conducted and working systems exist. The system includes filters or mirrors which eliminate the infrared portion of sunlight, delivering visible and some ultra-violet light. This "cold light" produces lowered air-conditioning loads. For each watt of artificial light which is displaced, a reduction of 1/3 watt in air-conditioning would also be expected.

This system offers a high quality light source with low heat gain. It also gives the occupants of the solar illuminated space contact with the outside sun and weather conditions. First cost is high, however, and it delivers very little light on cloudy days. In addition, variable voltage lighting is necessary for the backup source to maintain even lighting levels while saving electricity. These automatic lighting systems are being evaluated under current DOE programs.[1]

Benefit Analysis

The cost of light from fluorescent or incandescent lamps is 5 to 10 times the cost of electricity due to their low efficiency of about 20% and 10%, respectively. The cost per kwh of delivered light is $.20 for fluorescent, and $.40 for incandescent lamps at an electricity cost of 4¢ per kwh.

Energy savings would be the amount of artificial illumination displaced plus the reduced air-conditioning load. As stated above, for each watt of artificial light displaced, 1-1/3 watts of electrical power is conserved. Since the sunlight that is delivered is essentially 100% light (collector efficiency may be only 65%) one watt of solar sunlight will displace 5 watts of fluorescent or 10 watts of incandescent lighting load.

It has been estimated by one source[3] that the solar supplied light would cost $0.12 per kwh ($.035 per 1,000 Btu) a 40% savings over fluorescent and 70% savings over incandescent lighting. This estimate is based on mass production of the necessary hardware. The initial investment is $3,400 per kw of yearly average delivered light capacity. This would indicate a payback period of about 4 years for the initial cost of the system, not including air-conditioning savings.

Reliability of the system is highly dependent on good design and protection of the heliostat from the elements. A protective glazed enclosure[3] would cut maintenance and initial cost of the collector assembly.

Tracking systems are becoming widespread in the solar field, cost reductions improved reliability may be expected.

Schedule and Cost Estimate

The solar powered lighting system would require 5 months to complete.

It is estimated that 8 man-months will be required:

	Engineering	Technician
Research	2	
Design		
Fabrication and startup	3	3
Sub-total	5 mos.	3 mos.
TOTAL	8 man-months	

Personnel cost, including overhead and expenses for the above, \$32,000.
Equipment cost, $1m^2$ prototype, \$12,000.
The cost estimates are based on the references which follow.[2,3,4]

References

1. Iota Engineering, Inc., Manufacturer of variable voltage ballasts, 1735 East Ft. Lowell, Tuscon, Arizona 85719, Evaluated under Lawrence-Berkeley Laboratory Report LBL-7871, July 1978.

2. M.H. Duguay, Pers. Comm.

3. M.H. Duguay, Solar Electricity: The Hybrid System Approach, The American Scientist, Vol. 65, No. 4, 1977.

4. Donald Carson, Pers. Comm. Carson Astronomical Instruments, Inc., 120 Erbbe N.E., Albuquerque, N.M. 87123.

HEAT PUMP INTEGRATED - WASTE HEAT RECOVERY

FROM POWER PLANT FOR SPACE HEATING

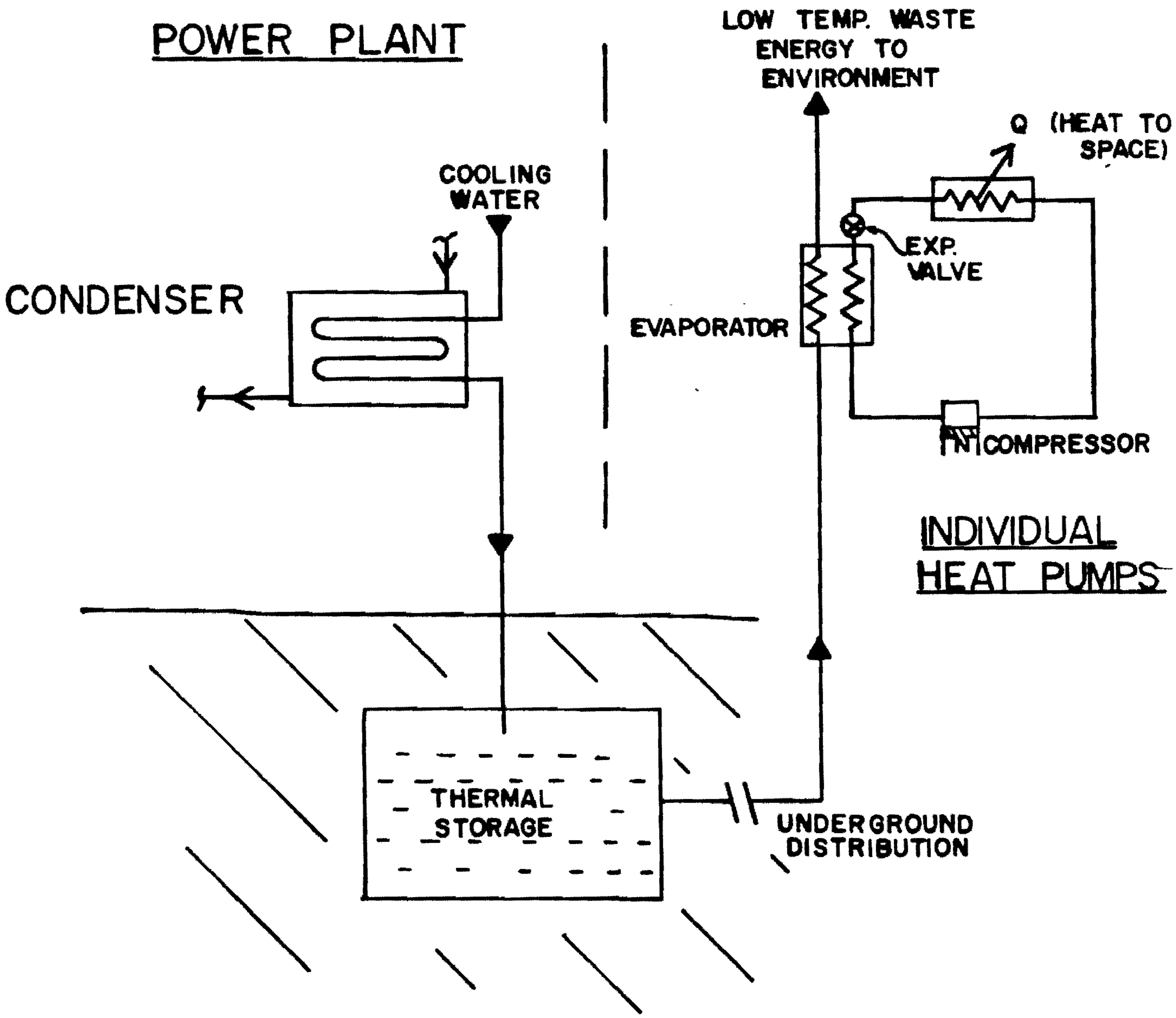
HEAT PUMP INTEGRATED - WASTE HEAT RECOVERY FROM POWER PLANT FOR SPACE HEATING

The proposed system uses heat pumps for the recovery of heat from low temperature heat sources such as the cooling water of the power plants. In this case the heat rejected by the steam in the condenser is carried by the cooling water by means of a distribution network to the heat pumps installed in the various buildings - residences, offices, laboratories etc., - over the entire area of the base. The heat pumps at the individual user locations extract this low grade energy and deliver it to the space at the desired temperature. The use of heat pumps will result in significant energy savings.

SYSTEM DESCRIPTION:

The system is shown in Figure 1. Cooling water at temperatures ranging from $55^{o}F$ to $80^{o}F$ enters the condenser of the power plant and picks up the heat of condensation of the exhaust steam from turbines or central cooling equipment. The water is heated to $95^{o}F$ to $100^{o}F$ and is distributed to the individual heat pumps through an underground piping network. The refrigerant in the heat pump picks up heat from this relatively warm water and delivers it to the space. The system uses an underground thermal distribution network and thermal storage.

Since the cooling water coming from the condenser serves as a relatively warm water heat source for the heat pump, the COP - coefficient of performance - of the heat pumps would be high and can result in significant energy savings.



HEAT PUMP INTEGRATED WASTE HEAT RECOVERY AND HEATING OF A COMMUNITY (AFB)

FIGURE I

The thermal storage can also be accomplished by means of an aquifer (Figure 2) technology is under development (Ref. 2).

ENERGY SAVINGS:

Based on the range of temperatures of the heat source, the integrated heat pump system can result in energy savings up to 40% of the energy consumed by conventional systems using scarce fossil fuels.

ADVANTAGES:

1) The heat pump system makes it possible to use the lowest cooling water temperatures which will allow lower exhaust pressures and increased power development.
2) Cooling towers and associated equipment are eliminated.
3) Furnace and the associated equipment are replaced by a relatively simpler heat pump system at the user's building.
4) The heat pump can be used for summer cooling also.

REFERENCES:

1) ASHRAE HANDBOOK AND PRODUCT DIRECTORY - I) Systems Volume 1976
II) FUNDAMENTALS 1977

2) Fred J. Molz, James C. Warman, Thomas E. Jones, and George E. Cook: Experimental Study of the subsurface transport of water and heat as related to the storage of solar energy.

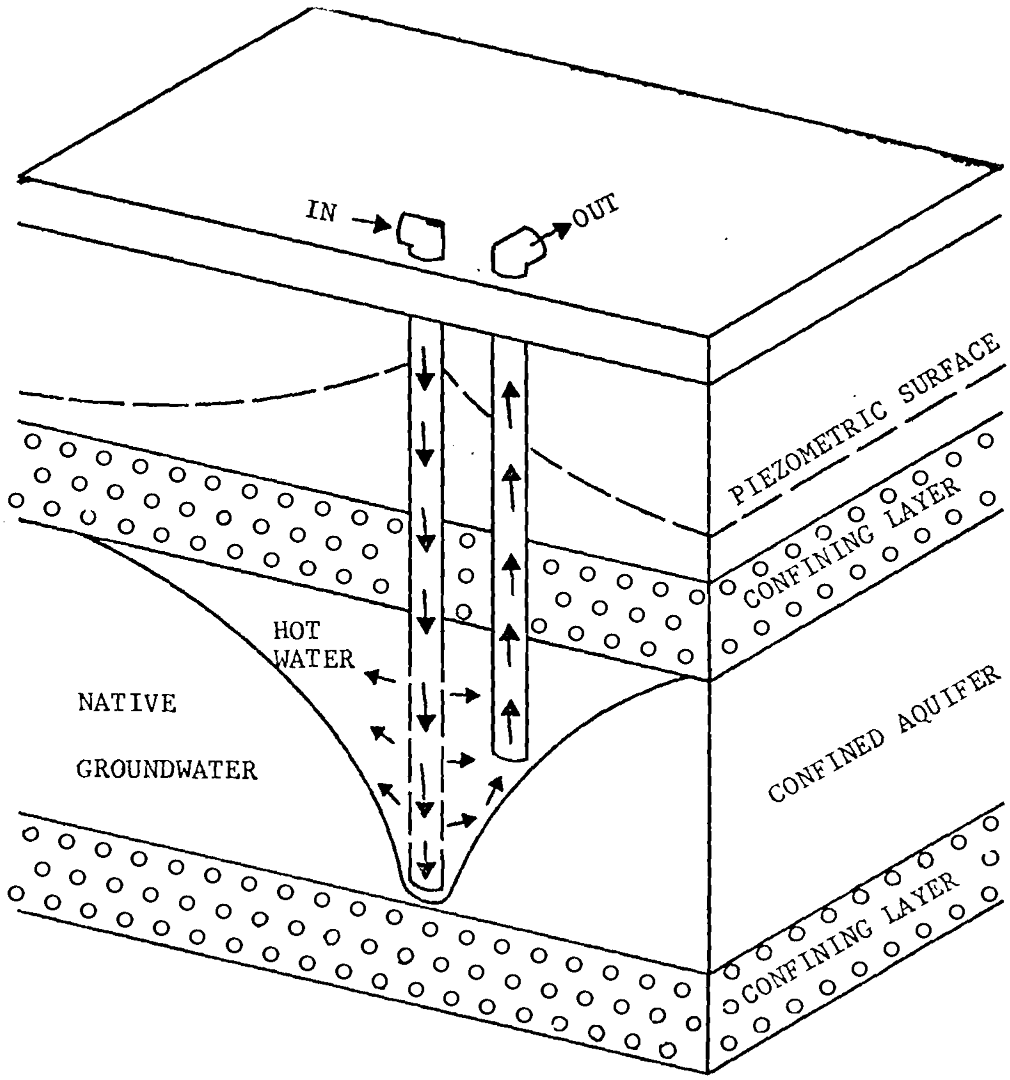


Figure 2. Aquifier

DEMONSTRATION ENERGY SYSTEMS FOR ISOLATED MILITARY APPLICATIONS

ENERGY SYSTEMS FOR ISOLATED MILITARY APPLICATIONS

Certain types of military outposts such as radar stations, radio relay stations, and navigational stations require an uninterrupted source of electrical energy. Currently, the power of these stations must be supplied by primary batteries, or gasoline or diesel generator sets when commercial power is not available. It is very costly to maintain a reliable source of power for these stations, not only from a mechanical standpoint but also from a resupply standpoint. The replacement of the existing power systems by power systems that rely on renewable technologies or advanced technologies could provide several benefits; e.g., increased reliability, reduce man-power requirements, reduce supply requirements and fuel savings. Not only does the value of these benefits increase as the cost of energy and man-power increase but the availability of renewable resources such as wind and solar could increase the availability of the isolated outpost to complete its mission.

In recent years, the Department of Energy has invested a great deal of research effort in developing photovoltaic energy systems, wind energy systems, and fuel cells. The electrical output of the fuel cells and the photovoltaic systems is DC power, and the wind energy system can be designed to produce DC or AC power. By the proper selection of components, a combined system could be designed that could be used in almost any area of the world. However, in order to be practical in a military sense, these energy systems must be modularized and produced in standard component sizes which could be easily integrated and yet provide the versatility which would be necessary to account for variations in individual sites.

The purpose of the proposed program is to determine the feasibility of utilizing multiple energy sources in a combined system to provide reliable and economical power for isolated military applications. The energy requirements of several types of isolated outposts will be analyzed and one type of outpost will be selected to be used to demonstrate the concept. A multisource energy system will be designed to provide both electrical and thermal energy. The performance of the demonstration system will be analyzed to evaluate the ability of the energy system to meet the mission requirements of the isolated post, and a cost-benefit analysis will be performed to determine the economic value of the system. The following is an outline of the proposed program.

ENERGY SYSTEMS FOR ISOLATED
MILITARY APPLICATIONS

A. Load Analysis

1. Identify candidate types of outposts

2. Select a specific type for demonstration

3. Categorize loads (electrical and thermal)

    a. peak demand

    b. average demand

    c. duty cycle

    d. type of power required

    e. reliability required

    f. type of equipment

B. Existing Power System

1. Identify types of power systems

2. Determine operating characteristics

3. Fuel requirements and costs

4. O & M costs

5. Transportation requirements and costs

6. Limitations and disadvantages

C. Identify Appropriate Technologies (Electrical and Thermal)

1. Photovoltaic (flatplate)

2. Photovoltaic (concentrating)

3. Solar thermal (flatplate)

4. Solar thermal (concentrating)

5. Wind energy conversion

6. O.T.E.C.

7. Fuel cell

D. Identify Support Systems

1. Energy storage (electrical)
2. Energy storage (thermal)
3. Voltage regulators
4. Safety systems
5. Inverters
6. Other

E. Demonstrate Concept Using Existing Technology

1. Select site of demonstration
2. Design integrated power system
3. Purchase equipment
4. Install power system
5. Operate power system
6. Evaluate operating characteristics
7. Evaluate effectiveness of system
8. Identify technical fixes to improve operating characteristics

F. Identify Future Trends in Load Requirements

1. Reduced an increased power requirement (e.g., utilization of integrated circuits)
2. Voltage control
3. Size of installation
4. Type of energy required

G. Define Standard Configurations for Militarization

1. Size of modules
2. Interface equipment
3. Common system components
4. Sizing guidelines

Manpower required will be approximately four man years over a 1 1/2 year period.

HARDWARE COST

1KW Flat Plate P/V	@ $20/W	$20,000
1.5KW Wind Generator System	@ $3000/KW	4,500
30KWH Battery storage	@ 750/KWH	22,500
2KW Invertor	@ 2.50/W	5,000
	Voltage control equipment	5,000
	Instrumentation	11,000
		$68,000

CONCEPT FOR A COMBUSTION RESEARCH LABORATORY

CONCEPT FOR A COMBUSTION RESEARCH LABORATORY

Introduction

In the time following World War II, natural gas and fuel oils became widely available, and at such low costs that these fuels effectively displaced coal and other fuels. With the advent of the "energy crisis" and sharp increases in cost and supply uncertainties, a need has developed to explore the feasibility of alternative energy supplies and to use energy resources more efficiently. From an operational standpoint, military bases must have a non-interruptable source of energy which necessitates self-contained energy sources on the base. Many technologies for self-contained combustion generated energy sources are in the developmental stage. In order to produce reliable and non-polluting energy, much research and development must be applied to these emerging technologies.

It has become a national policy to encourage conversion to coal firing, and much R&D effort is underway. Even the most dedicated coal enthusiast admits that natural gas and distillate oils present far fewer environmental problems than coal. These coal related environmental problems are recognized by the Department of Energy (DOE) which is supporting a great deal of coal combustion research.

Another fuel which is just now being recognized as a possible significant source of energy is that which is called biomass. Biomass is the inclusive name given to that combustionable material which may be generated by industrial or agricultural waste, municipal trash, and forest materials. It is characterized by being quite variable in compositions, moisture content, heating value, and availability. Against these characteristics it is thought in localized situations a valuable heat source which can be available at relatively low cost. The utilization of this material directly reduces our dependence on foreign fuel and provides local economic benefits.

Many of the concepts for advanced combustion systems have been proven to have potential for increased efficiency, low pollution, and alternate fuels usage. However, a major area that remains is the evaluation of a wide variety of alternate fuels which are available at a particular installation. There is a need to create a combustion laboratory facility which can serve the purpose of evaluating a wide variety of fuels under a wide range of operating conditions in the emerging combustion systems: i.e., fluidized beds, wood fuel gasifiers, and pyrolyzers.

Combustion Research Facilities

The proposed combustion research laboratory at the Wright-Patterson Air Force Base will serve as a test and development facility with efforts directed to the following areas:

1. Alternate Fuels Analysis
   a. chemical composition
   b. density
   c. moisture content
2. Alternate Fuels Testing
   a. handling and storage evaluation
   b. combustion efficiency
   c. ash content
   d. ash removal
   e. emissions analysis
3. Environmental Control Requirements
   a. air
   b. water
   c. ash disposal

Basic facilities will be required for the fuel evaluations and include:

1. Tri-fuel boiler for use with natural gas, fuel oil, and coal or wood.
2. Gasifier for use with wood and other biomass and industrial wastes.
3. Fluidized bed boiler for use with low and high sulfur content coal, wood chips and pellets, and industrial and urban wastes.

A considerable investment will be required to develop a capability for emissions measurements. The instrumentation and hardware for these measurements and evaluations include:

1. Particulate Measurements

   cascade impactors
   electrostatic size classifiers
   nephalometers
   mass and concentration monitors
   opacity meters

2. Gas Composition Measurements

   non-dispersive infrared for CO_1, CO_2, SO_x, NO_x

   hydrocarbon analyzer
   oxygen analyzer

3. Chemical Composition Measurements

   gas chromatographs

   gas chromatograph - mass spectrometer - chemical ionization, with computerized spectral search
   liquid chromatographs

The above hardware and instrumentation will provide a basic capability for a combustion research laboratory. More specialized hardware which is oriented towards basic research should be selected by the individual performing the research.

Estimated Budget

Depending on the size of the boiler, gasifier, and fluidized bed, the estimated initial cost of the proposed laboratory will be in the range of $800,000 to $1,000,000 for the equipment.

COMMERCIALIZATION INITIATIVES AND TECHNOLOGY TRANSFER

COMMERCIALIZATION INITIATIVES AND TECHNOLOGY TRANSFER

Commercialization of energy technologies

To support the national goal of early commercialization of emerging energy technologies, the initiatives taken by the Air Force at Wright-Patterson AFB will be used to disseminate energy information to appropriate segments of the private and military sectors. This thrust will be directed to using the energy systems to be constructed as training grounds for planners, architects, engineers, and business leaders in the private and military sectors. Experience gained in the design, construction, and operation of energy facilities will be transferred to these audiences through a vigorous program of short courses, workshops, and conferences, and will be used to create training materials for subsequent dissemination efforts. The commercialization thrust of this program will center around use of information derived from the specific projects for decision makers who must implement new energy options.

In order to utilize the specific projects to maximum advantage in commercialization activities, thorough project evaluations will be mandatory on a continuing basis. Data describing technical aspects will be needed, as well as accurate assessments of economic factors, both costs and benefits, associated with each project. With these data, the specific project can then serve as core sites for dissemination.

Dissemination of New Energy Technologies

In the WPAFB program, it is proposed that four specific groups be addressed in intensive education efforts. These are

1) Energy System Planners,

2) Private Sector Business Managers (CEO's),

3) Architects,

4) Engineers.

Each of these groups are key in the process of technology uptake and must have sufficient information to evaluate new energy alternatives and to implement new alternatives. Education of these groups will be conducted at WPAFB.

On-Site Activities

Short courses, seminars, and conferences will be held at WPAFB in facilities to be provided under this project. These facilities will include classrooms for lectures and conferences. The short course and conference agenda will include generic instruction in energy systems selections, design, and evaluation. The facilities will be made available for use by universities and energy systems contractors involved in specific WPAFB projects.

In addition to the lecture and conference facilities, sites of specific energy projects (cogeneration plans, biomass facilities, etc.) will be available for use as full scale training laboratories for participants in short course and conference activities. Direct observation of working systems during educational sessions will serve to better acquaint participants with operational parameters of new energy systems.

Extension Activities

The WPAFB commercialization program will include use of media instruction techniques as well as direct interactive techniques. Video-taped technical and management courses will be prepared for wide dissemination throughout the university and professional communities in the U.S. Specific project site activities will be included in the media education activities where appropriate.

Information from Specific Projects will be included in the Commercialization Project

To support the technology dissemination efforts of this project, substantial project documentation will be required. These data should be collected during an on-going project evaluation and should be consistent with dissemination to technical and business audiences. Data needs will be defined for each specific project and data will be collected to describe planning, design, construction, and operation of each project.

A Commercialization Program Plan will be developed utilizing a broad range of Resources

In order to define and implement this comprehensive program, it is proposed that a coordinating committee of senior level public and private sector leaders be established. This group would establish policy and general plans. To implement these plans, it is proposed that a prime commercialization contractor be given the responsibility for coordinating the day-to-day activities of the program. This prime contractor will be required to use a broad range of consultants and subcontractors.

The Commercialization Program should be initiated simultaneously with WPAFB Program Initiation

Planning for the commercialization should be initiated at the start of activities on-site at WPAFB. The plans developed need to be implemented at an early date consistent with project progress and will require lead time for preparation of facilities, materials, etc.

Commercialization Goals will be set

Specific targets will be established for dissemination to the four major groups identified above. These should include a target number of conferences and workshops. As initial goals, each specific project should have 4 to 6 associated short courses, seminars, or workshops in each calendar year.