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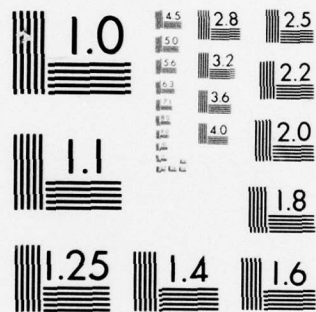
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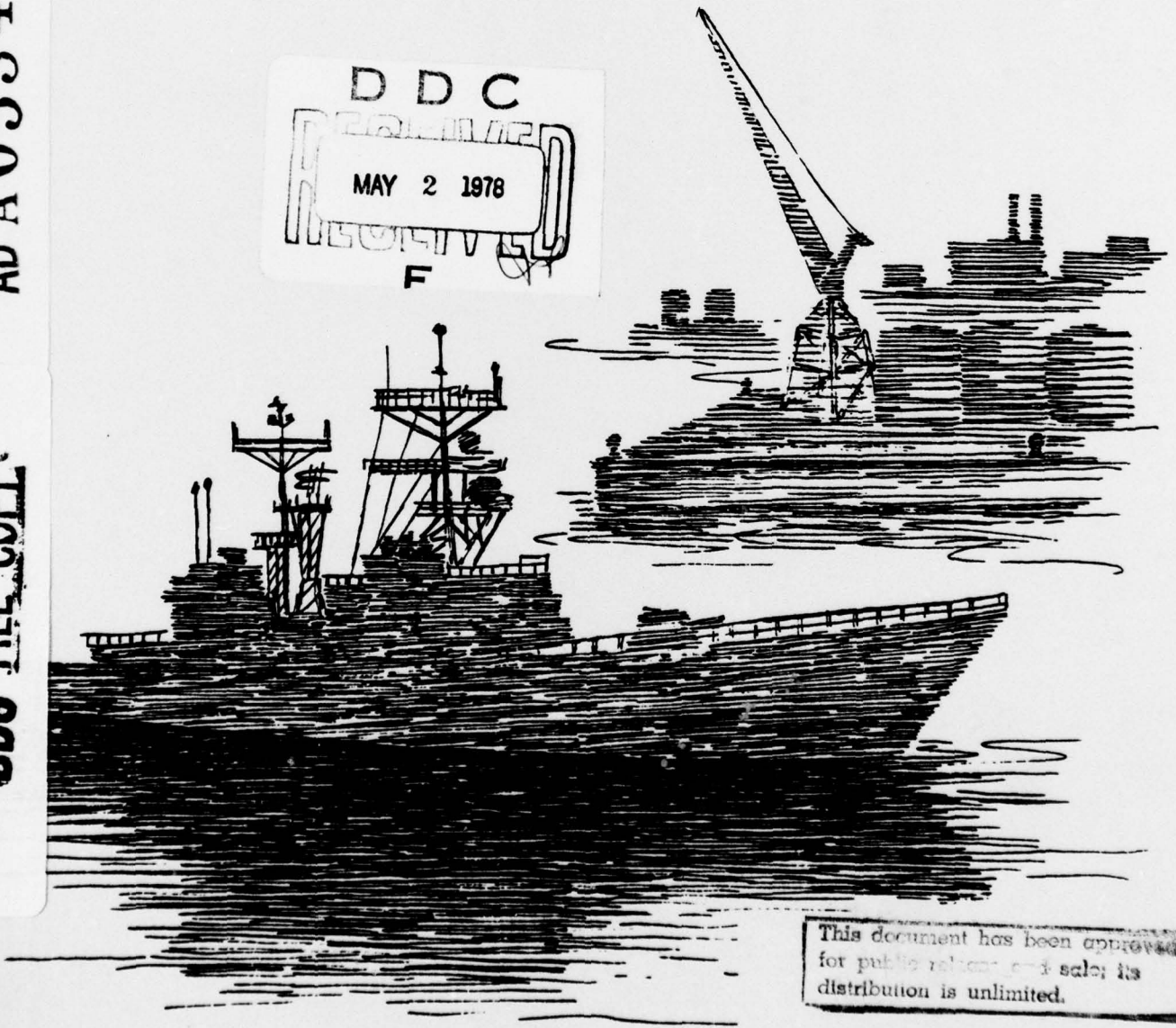


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U.S. NAVY ENERGY AND NATURAL RESOURCES
RESEARCH AND DEVELOPMENT OFFICE

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U.S. NAVY
ENERGY R&D PROGRESS
1977



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MARCH 1978

Prepared for: Chief of Naval Material

Prepared under the Direction of: U.S. Navy Energy and
Natural Resources Research and Development Office
CAPT T. F. Stallman, Director

U.S. NAVY ENERGY AND NATURAL RESOURCES
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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED	
U.S. Navy Energy R&D Progress, 1977.	Technical rept.	
6. AUTHOR(s)	7. PERFORMING ORG. REPORT NUMBER	
Natural Resources Directorate	14 TETRA A-938-78-361	
8. CONTRACT OR GRANT NUMBER(s)	15	
	N00014-77-C-0350	
	Item A004	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
Tetra Tech, Inc. 1911 North Fort Myer Drive Arlington, Va. 22209		
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE	
Director, Navy Energy and Natural Resources R&D Office Crystal Plaza #6, Rm. 606, Wash. D.C. 20360	Mar 1978	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	13. NUMBER OF PAGES	
	132	
	15. SECURITY CLASS. (of this report)	
	Unclassified	
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report)		
Approved for Public Release - Distribution Unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
Energy, Energy Research and Development, Energy Conservation, Synthetic Fuels, Energy Self-sufficiency, Energy Legislation, Shale Oil, Geothermal, Solar Energy, Wind Power		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
This U.S. Navy Energy R&D Progress report summarizes the progress of the Navy Energy R&D program from October through December 1977 and progress prior to October 1977 which had not previously been documented. Potential energy savings for each project is included.		

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PREFACE

This is the fifth in a series of periodic reports summarizing the Navy's progress on energy-related R&D projects in each of three areas—energy conservation, synthetic fuels, and energy self-sufficiency. The projects are supported by the Navy Energy and Natural Resources Research and Development Office (MAT-08T3).

The project status descriptions are based on reviews presented by Navy Systems Commands and laboratories. The section for each project entitled "Recent Progress" generally summarizes progress from October 1977 through December 1977; progress occurring before October 1977 and not reported previously is also included. In addition, estimates of potential energy savings (in barrels of oil equivalent) for the Navy are included for many projects. (The methodology used is not consistent, however, because different Navy laboratories derived the estimates.)

Appendixes include a list of Navy energy R&D projects, a summary of related R&D developments by industry and other government agencies during the reporting period, and brief discussions of recent legislation and national energy policies that directly affect the Navy.

The report complements the "U.S. Navy Energy R&D Program Plan, FY 1978-FY 1983."

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ABBREVIATIONS

AEUTB	Advanced Energy Utilization Test Bed
ASW	Antisubmarine warfare
BLAST	Building Load and System Thermodynamics
BOE	Barrels of oil equivalent
BOM	Bureau of Mines
BUMED	Bureau of Medicine
CEL	Civil Engineering Laboratory
CODOG	Combined diesel and gas turbine
COED	Char-Oil Energy Development
CONUS	Continental United States
DEIS	Defense Energy Information System
DFM	Diesel fuel marine
DFSC	Defense Fuel Supply Center
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DTNSRDC	David Taylor Naval Research and Development Center
EDML	Energy Data Mobile Laboratory
EFD	Engineering Field Division
EMCS	Energy Monitoring and Control System
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ERDA	Energy Research and Development Administration
ESI	Equivalent sphere illumination
FEA	Federal Energy Administration
HVAC	Heating, ventilating, and air conditioning
LANDIV	Atlantic Division
LASS	Loads and system simulation
LES	Low energy structures
MARAD	Maritime Administration
MIS	Management Information System

NAD	Naval Ammunition Depot
NADC	Naval Air Development Center
NAPC	Naval Air Propulsion Center
NARF	Naval Air Rework Facility
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration
NAVAIR	Naval Air Systems Command
NAVFAC	Naval Facilities Engineering Command
NAVMAT	Naval Material Command
NAVSEA	Naval Sea Systems Command
NAVSEC	Naval Ship Engineering Command
NBS	National Bureau of Standards
NCBC	Naval Construction Battalion Center
NRL	Naval Research Laboratory
NRMC	Naval Regional Medical Center
NSGA	Naval Security Group Activity
NSRDC	Naval Ship Research and Development Center
NTC	Naval Training Center
NWC	Naval Weapons Center
OCS	Outer Continental Shelf
O&M	Operations and maintenance
OMP	Organometallic polymer
PMTC	Pacific Missile Test Center
POM	Program Objectives Memorandum
PUF	Polyurethane foam
PWC	Public Works Center
R&D	Research and development
RD&D	Research, development, and demonstration
RDF	Refuse-derived fuel
RDT&E	Research, development, test, and evaluation
RFP	Request for proposals
SF ₆	Sulfur hexafluoride
SPR	Strategic Petroleum Reserve
STEM	Shipboard Total Energy Model
SYSCOM	Systems Command
USGS	U.S. Geological Survey
VCP	Visual comfort probability

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EXECUTIVE SUMMARY

The goals of the Navy energy R&D program are to reduce the Navy's reliance on foreign energy supplies, minimize the penalties imposed on its operations caused by increased fuel prices, enable the Navy to meet dated national energy directives, and begin the transition from petroleum-based energy sources to alternative sources.

The Navy's energy planning efforts and the formulation of Navy energy policy are based on a set of energy goals that parallel national and DOD goals. The Navy will meet these goals while maintaining the necessary level of military readiness and effectiveness. Those goals relating to energy conservation will be achieved through programs satisfying the requirements of Executive Order 12003, issued in July 1977, to reduce energy use in federally owned buildings and vehicles.

ENERGY CONSERVATION

Energy conservation is the most effective way to alleviate, in the near term, problems of increased cost and growing dependence on foreign oil supplies. Conservation is, in most cases, immediately applicable with short-term payback and contributes to attainment of national, DOD, and Navy goals, while the more advanced energy technology programs, such as synthetic fuels, require longer lead times for implementation.

Following the policy recommendations of the Defense Energy Task Group, the Navy is concentrating its energy conservation R&D effort on shore-based and shipboard energy conservation. (The Air Force is the lead Service for aircraft energy conservation R&D; the Navy supports this effort by establishing technology requirements and applying useful technologies to Navy aircraft.) The primary approach of the energy conservation R&D effort is directed toward the evaluation, development, and implementation of technologies or operational practices that will reduce energy consumption. In FY 1977, the total Navy energy conservation effort (both R&D and non-R&D) resulted in a total energy savings of 12.8 million BOE as compared with FY 1973 usage.

SHORE-BASED CONSERVATION

NAVFAC is responsible for energy conservation R&D at Navy shore facilities. CEL's Energy Program Office is the lead laboratory for this effort. The Navy is identifying energy technology requirements and building a technology base tailored to its needs. This is being accomplished primarily by assimilating advances made in the national energy program and applying the technology, where appropriate, to Navy shore-based facilities. These advances include:

- Improved construction materials, methods, and designs.
- Improved or advanced heating systems.
- Improved HVAC systems.
- Improved lighting systems and single-building control systems.
- Energy loss detection and measurement.
- Energy monitoring and control systems.
- Improved or advanced power cycles or energy utilization systems.

Among the recent accomplishments in the energy conservation R&D program were:

- Determination of the effect of insulation anomalies.
- Initiation of the selection process for an organic Rankine bottoming cycle system.
- Development of a lighting maintenance program.
- Procurement of a microprocessor time clock for use in environmental control systems.
- Use of the AEUTB in experimental tests.

Methods of detecting and measuring energy losses from buildings and pipelines by infrared and SF₆ tracer gas techniques were studied. Instrumentation packages to detect energy losses were procured and assembled for use in field surveys.

To increase building thermal efficiencies, the Navy continued its work on construction materials and methods with tests of wall panels to determine thermal, structural, safety, and related characteristics. One of the significant findings of this study was that small voids in ceiling or wall insulation greatly add to heat losses. Testing and evaluation also continued on the LES concept for new construction and retrofit applications. Construction of a LES test cell to demonstrate the louvered atrium concept was started.

Potential cogeneration sites were surveyed; more than 20 CONUS Navy bases were considered applicable. On the basis of the analysis, the Jacksonville, Florida, NAS/NARF was selected as the site for a cogeneration exemplar study. Selection of equipment for a joint Navy/DOE program to demonstrate an organic Rankine bottoming cycle at the NAS, Bermuda, power plant was started and is well under way.

EMCS work included effectiveness validation, study of expansion capabilities, determination of necessary evaluation criteria, study of advanced EMCS, and analysis of system economics.

Studies of HVAC systems continued in several different areas, and included:

- The identification of options for reducing HVAC energy consumption, including the technical feasibility, potential savings, and potential markets for alternative HVAC systems.
- A survey of 10 potential Navy sites for sea/lakewater cooling, which resulted in the selection of four sites for further evaluation.
- Measurements of seawater temperature, surveys of on- and offshore areas, and studies of biofouling in preparation for the design and installation of a prototype seawater cooling system at NSGA, Winter Harbor, Maine.

Evaluations of new energy-saving lighting systems and methods for implementing lighting maintenance at Navy facilities (such as a maintenance scheduling computer program) continued. In addition, development of a draft lighting applications report progressed.

CEL continued application engineering studies to provide technology transfer from CEL to NAVFAC and the EFDs. The dissemination of energy technology information in bulk occurs in a wide variety of ways, including overview brochures, the CEL Energy Newsletter, Techdata sheets, progress reports to NAVFAC, detailed handbooks, and formal CEL technical memoranda, notes, and reports.

SHIPBOARD CONSERVATION

NAVSEA has primary responsibility for shipboard energy conservation R&D. The program concentrates on reducing shipboard energy consumption through improved ship propulsion, more efficient auxiliary systems, improved operating procedures, and advanced techniques for reducing hull drag. DTNSRDC is the primary Navy laboratory conducting the shipboard energy conservation program.

The NAVSEA exploratory development (6.2) program is an ongoing effort to review and analyze the state-of-the-art of energy technology as applied to ships. The goal of this program is to reduce fuel consumption of the future fleet through the use of alternative propulsion and auxiliary systems. This effort has involved compilation of a data base representing actual shipboard auxiliary and propulsion systems. The data base includes such variables as performance, energy consumption, and risk assessment. The data are being used as a baseline to project future fleet requirements.

Several energy-intensive systems have been identified. Candidate modifications or replacements are expected to evolve into advanced or engineering development. HVAC, lighting, pumping, electric power generation, and other systems are being evaluated.

Computer modeling efforts in the exploratory development program include the Shipboard Total Energy Model, which allows integrated energy studies of shipboard systems to identify optimum energy conservation arrangements. A cost analysis program is also being used; this program identifies payback and life-cycle savings.

The advanced development (6.3) program supports technologies that evolve from the exploratory development R&D programs. The program consists of three major efforts. One, advanced ship components, includes model tests and hardware demonstrations of machinery systems and components that have the potential to reduce fuel consumption. The projects include propulsion-derived ship service power, reverse osmosis desalination, diesel noise analysis, heat powered air conditioning, and advanced pumping systems. Another major effort of the advanced development program is biofouling prevention and removal. This effort includes identification of improved biofouling prevention and removal techniques; the laboratory development, test and evaluation of organometallic polymer paints to prevent fouling for dramatically extended periods; and development of ultrasonic techniques for preventing marine growth in areas inaccessible to conventional cleaning techniques. The third major area of the program includes evaluation of alternative hull designs that will reduce drag and fuel consumption.

The NAVSEA engineering development (6.4) program is directed toward at-sea test and evaluation and full-scale land-based evaluation of improved ship's systems and operations affecting energy consumption. The projects in this program include:

- Fuel oil stripping
- Stack gas analyzer
- Machinery optimization
- Performance monitoring
- Water resources management
- Antifouling coatings
- Hull cleaning systems and procedures
- 2,000 kW quiet diesel generator
- Improved combustion systems.

SYNTHETIC FUELS

The Navy's main interest in synthetic fuels is directed at reducing its dependence on foreign oil. Synthetic fuels are derived from domestic resources of oil shale, tar sands, and coal, which are considered inexhaustible through the next century. NAVFAC, NAVSEA, and NAVAIR, through cooperative programs with DOE, are testing synthetic fuels to determine their usefulness as military fuels (JP-4, JP-5/Jet-A, DF-2/DFM, gasoline, and heavy fuel oil). Potentially useful fuels are being tested by the Navy in both small- and full-scale hardware to determine whether they are suitable for Navy needs and compatible with Navy equipment.

While the Navy is interested in evaluating all synthetic fuels—whether derived from oil shale, tar sands, or coal—the R&D program emphasizes tests of fuels derived from shale oil. Fuel derived from domestic tar sands will be evaluated as soon as a domestic industry appears to be commercially viable. Some coal-derived crude from the COED project has been tested. Other fuels derived from coal will be tested when the synthetic crudes are available from coal processes considered to be commercially viable for the production of military specification fuels.

Most programs are temporarily idle, awaiting delivery of refined fuels from the Navy's 100,000 barrel shale oil program. Production of 100,000 barrels of crude shale oil is expected to be completed near the end of FY 1978, and refining will begin in early 1979. The fuels are scheduled for delivery in mid FY 1979.

Shipboard atmospheric surveys of four ships—U.S.S. Hewes (FF-1078), U.S.S. Talbot (FFG-4), U.S.S. Saratoga (CU-60) and U.S.S. Elliot (DD-967)—were conducted. The final report is being prepared.

Work is being done to compare potential health effects of using typical synthetic fuels with those of using conventional fuels, particularly aboard ship. Three-month inhalation studies of both conventional JP-5 and conventional DFM were initiated to obtain baseline data for use in comparing the toxicological effects of conventional fuels with those of synthetic fuels.

ENERGY SELF-SUFFICIENCY

In its energy self-sufficiency effort, which began in FY 1973, the Navy is developing the capability to use local, renewable energy sources at both remote and domestic bases. Self-sufficiency R&D is focused on tests and evaluation of various energy systems being developed by other federal agencies or by the Navy in conjunction with other agencies, such as DOE and EPA, and EPRI. Systems using solar, wind, waste conversion, and geothermal energy are being considered. The Navy is also developing the capability to replace liquid hydrocarbon fuels at domestic bases with more abundant fuels, such as coal. NAVFAC is responsible for energy self-sufficiency R&D; CEL is the Navy laboratory primarily responsible for conducting the self-sufficiency R&D projects.

Activities to develop geothermal resources on Navy bases have been a major part of the self-sufficiency effort. NWC, China Lake, is the primary geothermal research activity. At the Coso thermal area at NWC, a production size well has been successfully drilled to 1,478 meters, where temperatures up to 188° C were recorded. Further temperature logging and flow tests are being conducted; environmental issues, as well as other factors of development are being studied; and the technical feasibility of transporting geothermal fluids from Coso to main base activities is being evaluated.

At Adak, Alaska, completion of geophysical studies resulted in the selection of drill sites. Three holes were drilled: one was drilled to only 322 meters because of hole squeeze problems, but heat flow measurements will be taken both there and in the second hole, which was drilled to 628 meters. The bottom-hole temperature in the second hole was 66° C, which is hot enough to provide a source of heating water. Drilling of the third hole was stopped at 37 meters. A contractor is studying the engineering and economics of piping geothermal heating fluids at Adak; results look promising.

Preliminary environmental assessments of drill sites proposed at NAD, Lualualei, Hawaii, were completed.

A final report was issued examining the legal and institutional problems of exploring and developing geothermal resources on and adjacent to Navy property. Reports on the effect of geothermal development on Navy missions have also been written.

Studies of heat pumps and advanced HVAC systems using local renewable resources continued. Both hardware and computer simulations were designed for analysis of solar augmented heat pumps. A report was issued on life-cycle cost analysis of solar absorption air conditioning; results indicate that these systems will be economically competitive by 1985. Contract work on thermodynamic analysis of two-stage ammonia-sodium thiocyanate absorption refrigeration systems was initiated.

In waste-recovery projects, plans for combustion tests of densified refuse-derived fuel were initiated and a contract was awarded for a 72-hour operating test of a packaged heat recovery incinerator. NWC continued its designing and testing of a system to convert solid waste to gasoline.

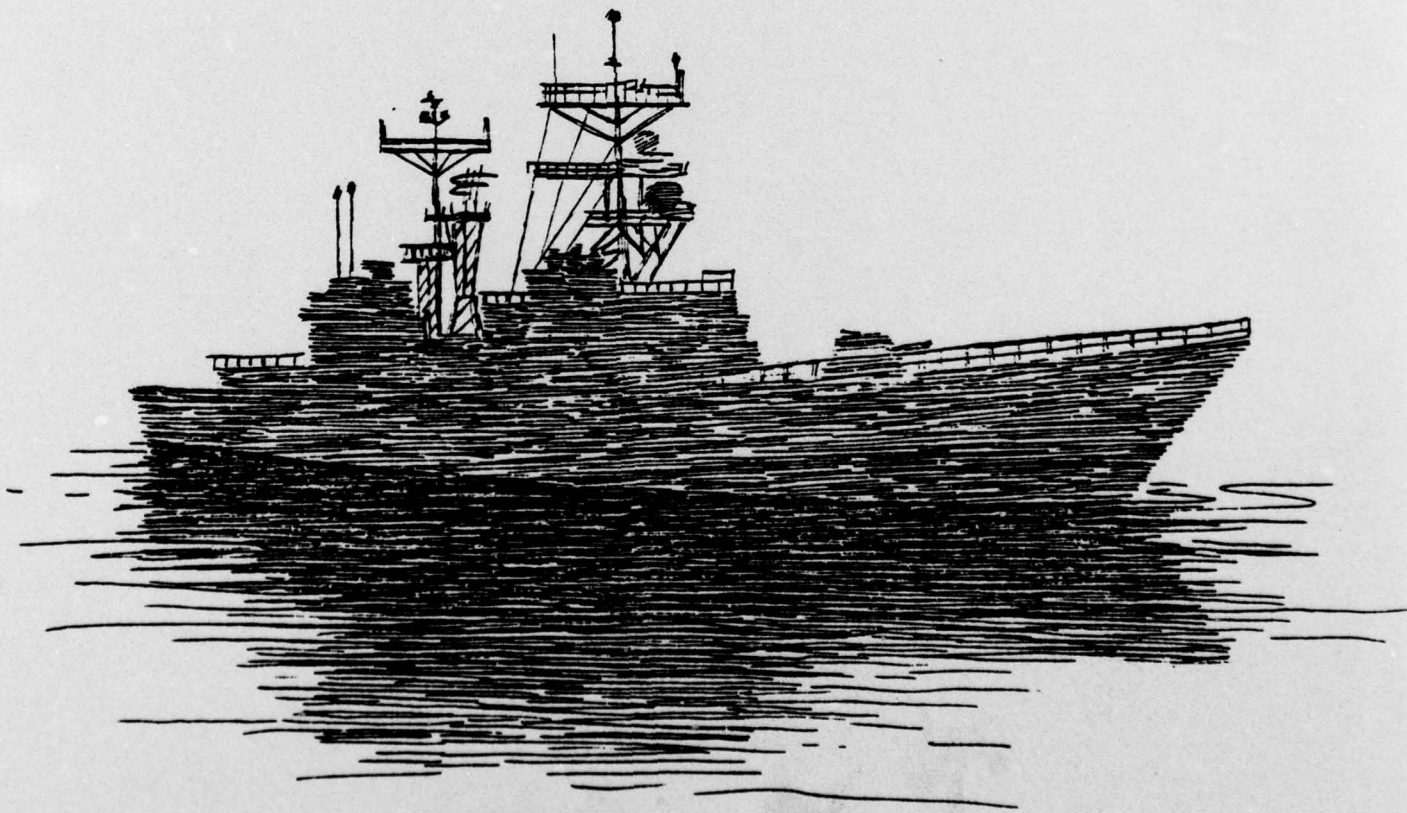
In its solar program, the Navy is monitoring the nationwide effort in solar technology and preparing for use of commercial solar energy conversion hardware at Navy facilities. Three solar collectors were tested on CEL's test stand; the flat-plate collector, tested according to the NBS format, showed efficiencies of 40 to 75 percent. A solar system to be installed on the test stand was designed and analyzed by computer. Evaluation of the feasibility of using photovoltaic systems at Navy bases has focused on preliminary feasibility studies and a cost analysis.

Desalination plants are operating at several naval facilities around the world. At some locations, the insolation level is high enough to permit efficient use of solar desalination systems. The Navy has been conducting technical and economic studies of such systems. An economic analysis of various solar desalination systems for supplying water at Navy bases was completed, and bench experiments with a solar still were started.

The Navy identified some bases at which the wind resource is sufficient to produce electrical power at a cost competitive with conventional resources. Wind velocity and power duration curves are being developed for several other promising Navy sites. Small, commercially available, wind generators are being tested and modified as necessary. A 5 kW system tested at Laguna Peak will be tested further at San Nicolas Island, where the plant should generate about 11,500 kWh per year. Also, a $\frac{2}{3}$ kW wind generator is operating well at the AEUTB.

Two new projects were started during the reporting period: fluid mechanical solar tracker and heat of solution air conditioning.

ENERGY CONSERVATION



ENERGY CONSERVATION PROJECTS

SHORE-BASED CONSERVATION

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AIRCRAFT FUEL CONSERVATION

AIRCRAFT FUEL CONSERVATION

Sponsor: NAVAIR
Performer: NADC

Program Element 62765N

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ENERGY OPTIMIZATION HANDBOOK FOR NAVY BASE PLANNING

Sponsor: NAVFAC
Performer: CEL
Contact: C. Parker

Program Element 62765N

OBJECTIVE

The objective is to provide a handbook of predetermined optimum mixtures of environmentally driven power systems and energy conservation systems for naval applications.

TECHNICAL APPROACH

Critical operational and economic parameters for conservation devices and power systems will be identified and formulated for quantification suitable for use in a systems optimization procedure. Technical inputs from applications engineering, as well as other engineering divisions with conservation and power system assignments, will form the basis for formulating unit characteristics. Since the development of an energy optimization procedure encompasses a large volume of technology yet to be developed, a number of specific products of limited scope will be defined.

The basic optimization procedure will be available as an approximate method using parametric curves and hand calculations, and also in a computerized version for more sophisticated computation. Documentation of the optimization procedure will be in the form of an energy optimization handbook for Navy base planning and will be updated periodically.

SUMMARY OF PAST PROGRESS

An economic analysis computer program was identified as compatible with NAVFAC P-442, "Economic Analysis Handbook." Sensitivity analysis subroutines were added to the optimization model. Critical parameters were formulated, and a draft report prepared.

RECENT PROGRESS

Work continued on the computerized optimization model. Recent activities involved ensuring that the optimization model is properly adapted for Navy use.

EXISTING ENERGY MONITORING AND CONTROL SYSTEMS

Sponsor: NAVFAC
Performer: CEL
Contact: D. Johnson

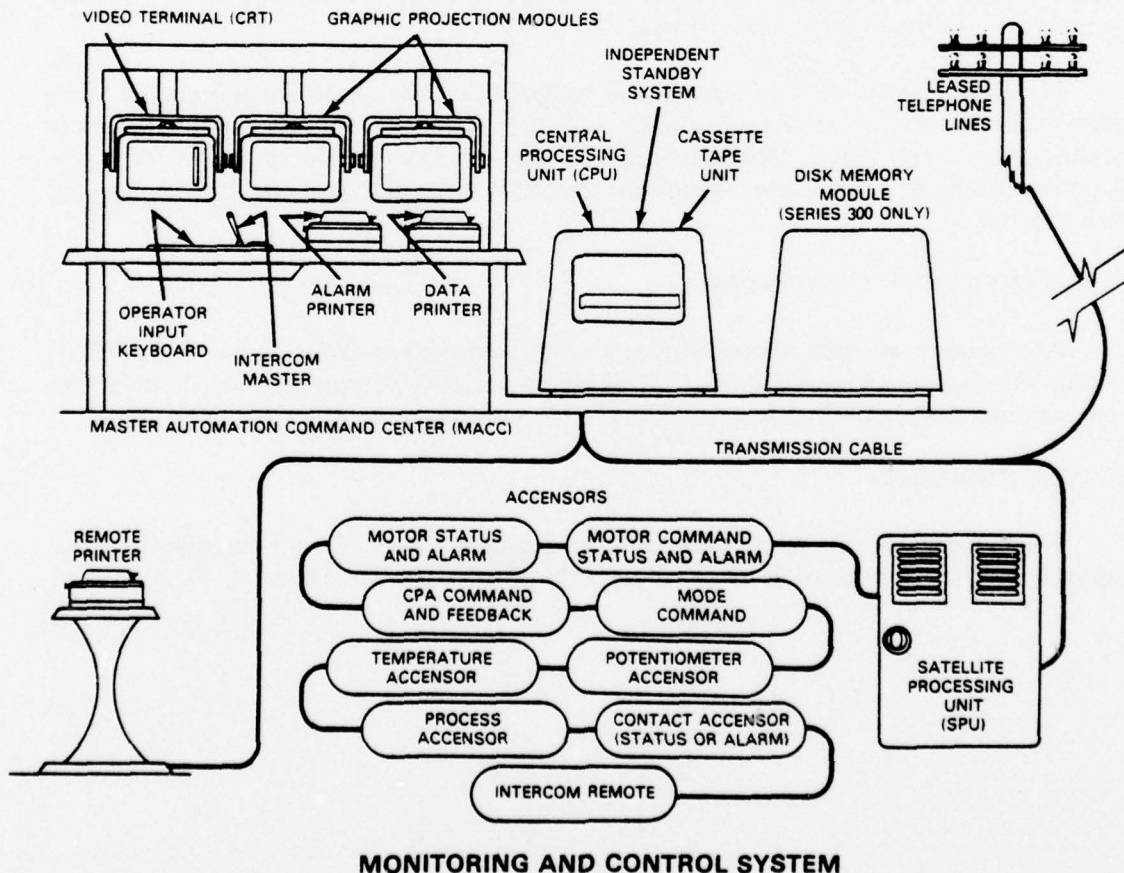
Program Element 62765N

OBJECTIVE

The objective of this project is to determine the additional costs and problems that arise from expansion of existing EMCS.

TECHNICAL APPROACH

Existing EMCS will be evaluated for information that affects future procurement and system development. This information includes system costs; economic and operational benefits; relative utilization of system features; system shortcomings and desirable additions; and operation and maintenance problems for the system and components, point selection, and other related parameters. These data will be used to develop site survey and project



development methodology, as well as guidance for analyzing system economic effectiveness.

SUMMARY OF PAST PROGRESS

The Camp Pendleton and Long Beach Naval Hospital Honeywell Delta 2000 System was studied. Various methods to expand and update EMCS, primarily through the utilization of techniques developed by software firms using off-the-shelf minicomputers, were studied. A contract was let to Stagg Systems to complete the study and to develop the best approach.

RECENT PROGRESS

A technical memorandum on expansion of existing EMCS was issued. An existing EMCS was selected, and a design was completed incorporating a high-technology retrofit to optimize its performance.

Guidelines were issued for dead band control. In addition, thermostat cycling tests were performed in the AEUTB, and a technical memorandum issued.

Investigations continue on improvements to existing systems using new developments in EMCS hardware and software.

Estimated energy savings are 1,800,000 BOE per year.

DOCUMENTATION

"In-Service Evaluation of Camp Pendleton Monitoring and Control Systems," TM M-62-76-14, July 1976.

ADVANCED ENERGY MONITORING AND CONTROL SYSTEMS CONCEPTS

Sponsor: NAVFAC
Performer: CEL
Contact: D. Johnson

Program Element 62765N

OBJECTIVE

The objective of this project is to evaluate advanced EMCS. High-technology computer systems and their effect on energy monitoring and control are being emphasized.

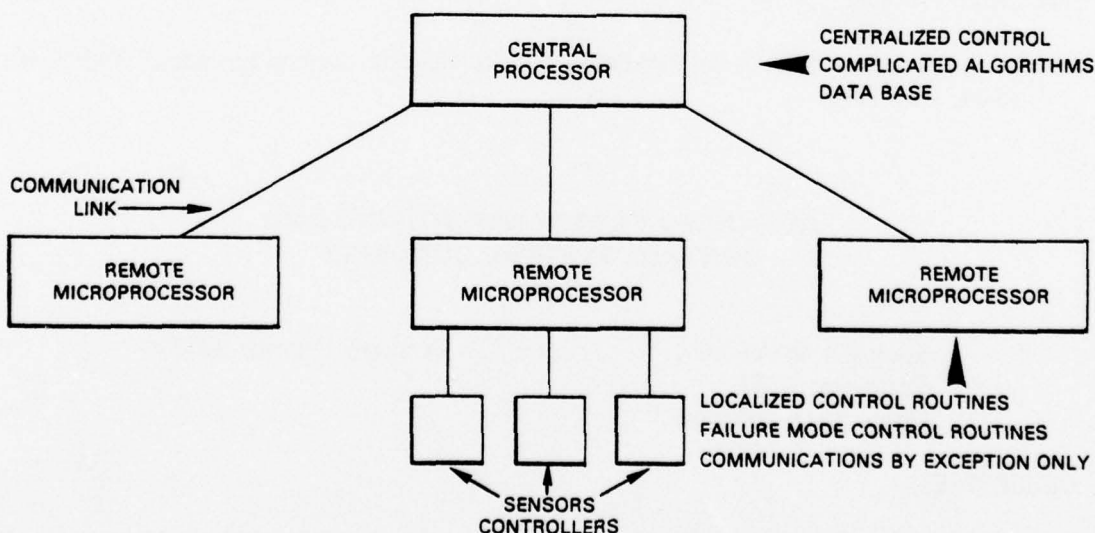
TECHNICAL APPROACH

Detailed operational capabilities of representative systems will be investigated, with particular emphasis on high-technology computing systems. The cost-effectiveness of a building-block approach to energy control will be analyzed. This approach involves using microprocessor technology in small, inexpensive building blocks to fit facility size and complexity, with a minimum of cost and interfacing complexity to add additional features. The information will be used to provide engineering guidance for future Navy applications. The use of computerized systems for analysis of load performance and development of optimizing control strategies will be investigated.

A high-technology system will be procured to develop a cost profile for retrofitting a system that is not meeting operational needs. Analysis tools will be included so that the operational and economic effectiveness of the retrofit can be determined to provide a data base for improving other Navy systems.

RECENT PROGRESS

This project began in FY 1978. Preliminary analyses indicate several distinct advantages of advanced EMCS concepts; demand on central processor and communications is lower, system availability and flexibility is greater, costs are reduced, and security is enhanced.



ADVANCED EMCS CONCEPT OF DISTRIBUTED PROCESSING

Two experimental installations of microprocessor time clocks have been built at CEL and NWC, China Lake. The one at CEL controls steam valves, and the one at NWC controls one air handler and monitors the operation of four.

Estimated energy savings are 1,300,000 BOE per year.

ALTERNATE HVAC SYSTEMS STUDY

Sponsor: NAVFAC
Performer: CEL
Contact: A. McClaine

Program Element 62765N

OBJECTIVE

The objective of this project is to provide Navy designers and planners with tools to aid in the design and choice of alternate HVAC systems capable of reducing energy consumption and system cost. The project is directed at providing guidance to design systems with the lowest life-cycle cost.

TECHNICAL APPROACH

Air conditioning systems employed a majority of the time at part load conditions will be compared. The effects of various climates on the systems will also be studied. Finally, design concepts will be investigated to determine how they can be integrated with existing systems. Upon completion of the analyses, a recommendation will be made to demonstrate the design principles established. Further investigations and development efforts are planned to investigate wind powered heat pump systems, solar regenerated desiccant dehumidification, passive HVAC systems, condenser coil efficiency monitors, and solar reheat systems.

SUMMARY OF PAST PROGRESS

The experimental approach to the investigation of air conditioning systems for efficient operation at part load operations was defined. The statement of work for this investigation was written, and a contract awarded to Lawrence G. Spielvogal, Inc., Consulting Engineers.

RECENT PROGRESS

An NBS report, "NBS Building Science Series 79," was evaluated for its applicability to this Navy project.

Options for reducing HVAC energy consumption, including feasibility, potential savings, and potential markets, are being defined. The results will be documented in a technical

memorandum at the end of the second quarter of FY 1978. The contractor has been modeling existing Navy buildings, and will recommend alternative systems based on computer analysis.

Estimated energy savings are 57,300 BOE per year.

CONSTRUCTION METHODS AND MATERIALS

Sponsor: NAVFAC
Performer: CEL
Contact: E. Vinieratos

Program Element 62765N

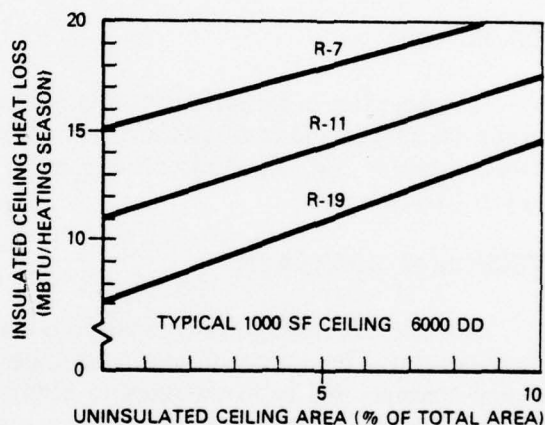
OBJECTIVE

An investigation is being conducted to determine what information on energy conservation is lacking and to recommend the steps necessary to obtain the required data. A new design concept for thermal buffer zones is being investigated to determine its applicability and cost benefits for new and retrofit Navy construction. The achieved versus theoretical values of insulation in Navy housing and commercial buildings are also being determined.

TECHNICAL APPROACH

Construction design for energy conservation depends on the properties of the materials used in the building envelope structure. The required information, including thermal properties, structural characteristics, fire characteristics, and moisture resistance, is generally available for building materials that have been used in the past. Such information will be available soon for many of the newer construction materials.

New construction materials will be surveyed to determine their energy conserving properties and fire safety, based on known characteristics of the specific materials used. The thermal and moisture characteristics of roofing and insulation designs will be determined; new roof and wall configurations, including thermal buffer zone concepts, will be investigated. Existing insulation values will be tested to obtain a significant statistical base for extrapolation to all Navy buildings.



CONSTRUCTION ANOMALY WITH CEILING INSULATION VOIDS

SUMMARY OF PAST PROGRESS

A contract was awarded to Johns-Manville R&D Center in December 1976 for building and testing construction anomaly wall panels. A total of 10 panels were constructed.

The preliminary draft of a material properties catalog was submitted by Sysdyne, Inc. Review of the draft indicated that further development of the catalog was worthwhile.

RECENT PROGRESS

The Johns-Manville contract to build and test construction anomaly wall panels was completed in November 1977. One of the significant findings of this effort was that voids in ceiling or wall insulation (for the passage of wires or pipes) greatly add to the heat loss of the building.

Analysis of the construction materials catalog for building energy conservation continued. As a result of this study, CEL will be cooperating closely with DOE, which is undertaking a similar effort.

HEATING AND COOLING LOADS COMPUTER SIMULATION

Sponsor: NAVFAC
Performer: CEL
Contact: E. Vinieratos

Program Element 62765N

OBJECTIVE

CEL is assisting, in a joint federal effort, to develop further the LASS computer model. The intent of this project is to develop the capability to simulate building thermal loads and to expedite the analysis of building thermal loads to assist the NAVFAC EFDs.

TECHNICAL APPROACH

Infiltration characteristics in typical Navy structures will be measured using both the Canadian Research Council's pressurization/depressurization method and NBS's tracer gas decay rate method. The data will be used to improve the infiltration calculations in the computer simulation. CEL will analyze available building thermal load simulation programs and select the best for use by EFDs in predicting building thermal loads.

RECENT PROGRESS

This project began in FY 1978. Several of the available computer simulation programs were analyzed for their adaptability to Navy usage. On the basis of a preliminary analysis,

the BLAST program has been found to be the most applicable to Navy needs. This program is a second-generation, simplified version of LASS.

LIGHTING DESIGN CRITERIA FOR NAVY APPLICATIONS

Sponsor: NAVFAC
Performer: CEL
Contact: W. Pierpoint

Program Element 62765N

OBJECTIVE

The objective of this project is to perform laboratory and functional experiments to examine the effects of lighting quality, as represented by ESI and VCP standards, and energy consumption.

TECHNICAL APPROACH

A computer program will be developed for calculating ESI and VCP in rooms with artificial and natural light sources. A complex computer program must be developed to optimize the trade-off between energy consumption and adequate illumination. To date, there are no existing computer programs that calculate ESI for daylight contributions in addition to the artificial lighting. The computer program to be developed will be designed to include total light contributions, to compute the effects on daylighting control systems, and to provide analysis of the design for quality of light. Lighting design and applications handbooks will be written to provide theoretical and practical guidance for using the computer program to best advantage.

SUMMARY OF PAST PROGRESS

Contracts for the lighting design handbook, the computer program, and the lighting applications handbook were awarded. The lighting design handbook and the computer program with a user's handbook were completed and forwarded to CEL.

RECENT PROGRESS

Computer system incompatibility and personnel changes delayed the implementation of the computer program onto the Navy's computer system. Most of the recent effort has involved work to solve these problems. In addition, work continued on developing a draft lighting applications report.

Estimated energy savings are 385,000 BOE per year.

DOCUMENTATION

"High Intensity Discharge Lighting: Color and Energy Considerations," TM M-62-77-18, September 1977.

"Automatic Light Sensing and Control of Lighting Systems for Energy Conservation," TN N-1486, June 1977.

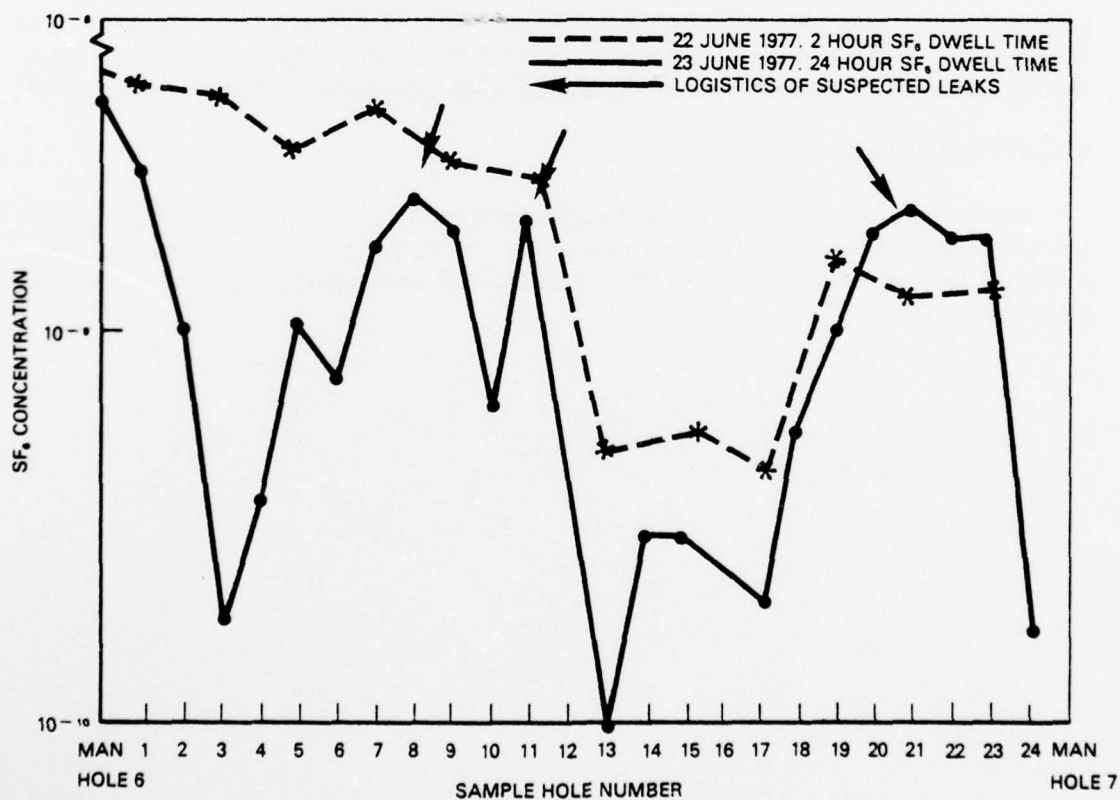
MEASUREMENT OF ENERGY LOSSES IN PIPELINES

Sponsor: NAVFAC
Performer: CEL
Contact: J. King

Program Element 62765N

OBJECTIVE

The objective is to evaluate and use instrumentation to locate and quantify energy losses from steam, air, water, and gas pipelines, both exposed and buried.



EXAMPLE OF FIELD TEST RESULTS FOR
ENERGY LOSS MEASUREMENTS IN PIPELINES

TECHNICAL APPROACH

Detection and measurement of energy losses in pipelines will be pursued under this work unit. Primary emphasis will be on steam and compressed air lines where losses are the most costly; however, gas and water lines will also be considered. SF₆ leak detectors will be tested extensively to determine required SF₆ concentrations, injection techniques, required SF₆ dwell times in pipes, SF₆ diffusion time in various soils, required pressurization, and operating characteristics of selected commercially available leak detectors. Attempts will be made to quantify steam leaks in underground lines after the leaks are detected by infrared or SF₆ inspection. SF₆ leak detectors will be evaluated to determine how well they assess the size of leaks. Types of underground conditions (wet or dry soil, standing water, tunnel, direct burial, etc.) will be considered for the effects of masking the location and magnitude of leaks. Attempts will be made to develop techniques and instrumentation for making point-to-point steam line measurements so that overall losses can be determined.

SUMMARY OF PAST PROGRESS

Information has been collected from several Navy bases having suspected problems, and has been requested from other bases. Available literature on the safety aspects of SF₆ leak detectors was reviewed. No safety problems were found for this particular application because the SF₆ concentration needed for leak detection is low. Two brands of SF₆ leak detectors are on hand and are being field tested. A series of field tests was conducted on a Ric-wil steam distribution system at NARF, North Island, California. Several leaks were indicated but have not been verified. A report on SF₆ leak detection done to date was drafted.

RECENT PROGRESS

Documentation of test procedures and field test results using acoustic, tracer, infrared, and temperature/heat flux techniques continued. The purpose of these activities will be to refine the test procedures, define their limitations, and determine the accuracy of locating leaks in pipelines.

MEASUREMENT OF BUILDING ENERGY LOSSES

Sponsor: NAVFAC
Performer: CEL
Contact: J. King

Program Element 62765N

OBJECTIVE

The objective is to develop and standardize techniques for measuring air leakage rates of Navy buildings.

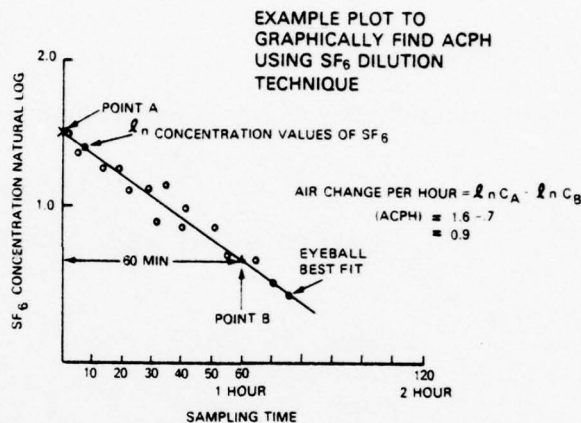
TECHNICAL APPROACH

The state-of-the-art of technology on aerial and ground infrared survey techniques and equipment will be monitored. Heat loss data from the infrared survey will be quantified. This effort may include the use of a temperature comparator, K-factor meter, heat flux meter, or an analytical technique that accounts for wall and roof thermal transients. Detection and measurement of infiltration losses from buildings are also included in this project. Pressurization equipment and an SF₆ chromatograph procured in FY 1976 will be used to determine component and total infiltration in typical Navy family housing units. Attempts will be made to correlate results from pressurization and SF₆ tests so that a simplified pressurization setup using components specifically sized for housing units can be developed.

SUMMARY OF PAST PROGRESS

Equipment procured for infiltration measurements by SF₆ tracer gas dilution and pressurization techniques has been assembled and checked out. Contracts are being maintained with industry, ASTM, and other government agencies involved with infiltration and thermography applications. Two sets of infiltration measurements were made in two family housing units at Norfolk, Virginia, in lieu of similar tests originally scheduled at NCBC, Port Hueneme, California. A meeting at DOE on thermography requirements for energy conservation was attended, and the DOE draft contract report reviewed.

In addition, pressurization equipment was installed on the AEUTB, and tests were conducted using SF₆ and pressurization techniques. Information on some aerial infrared survey methods used by the Army and Air Force was collected. Pyroelectric Videcon (non-cryogenic) infrared scanners were inspected.



MEASUREMENT OF BUILDING ENERGY LOSSES

RECENT PROGRESS

Data collection and analysis of infiltration loss measurements continued in conjunction with ASTM. The CEL staff continued to monitor new equipment and procedures for detecting and measuring building energy losses. Among these are Vanscan by Daedolus, aerial infrared with military equipment, pyroelectric videcon infrared, low-cost X-ray methods with a CRT, infiltration work of others, and other tracer gas applications.

Estimated energy savings are 3,000,000 BOE per year.

DOCUMENTATION

"Air Leakage Measurements in Navy Housing in Norfolk, Virginia," CR 77.016.

ENERGY SYSTEMS PLANNING AND OPTIMIZATION

Sponsor: NAVFAC
Performer: CEL
Contact: T. Shugar

Program Element 62765N

OBJECTIVE

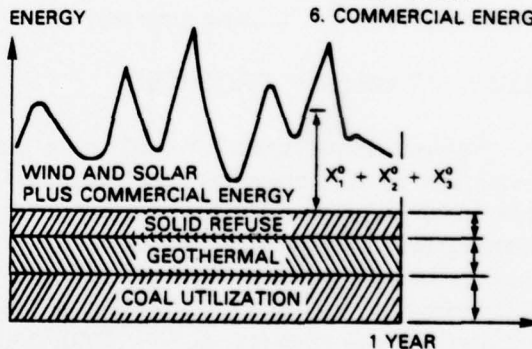
The objective of this project is to survey the Navy shore establishment to determine the economic feasibility of using alternative energy systems, and to provide economic data for planning the development of such systems.

TECHNICAL APPROACH

An economic analysis model will be developed which emphasizes the use of optimization techniques and the digital computer. The central component of the model is an optimization scheme that minimizes the uniform annual cost of supplying the electrical and thermal energy demand of a Navy base subject to various physical, economical and environmental constraints. The optimization is carried out over a specified life-cycle period and, subsequently, repeated according to the requirements of an appropriate sensitivity analysis. Admissible alternative energy system

OPTIMAL SOLUTION $\underline{X}^0 =$
 $(x_1^0, x_2^0, x_3^0, x_4^0, x_5^0)$

1. SOLAR
2. WIND
3. GEOTHERMAL
4. COAL UTILIZATION
5. SOLID REFUSE
6. COMMERCIAL ENERGY



CONCEPTUALIZED OPTIMAL SOLUTION

candidates for supplying energy at Navy bases are any one or combination of solar, wind, geothermal, coal gasification, solid refuse conversion, and commercially purchased energy.

Once developed, the economic analysis model will be applied on a base-by-base schedule where virtually all Navy bases will be included, both remote from and contiguous to commercial power grids.

SUMMARY OF PAST PROGRESS

The optimization scheme was programmed, exercised, and validated with several small benchmark problems. In addition, an abbreviated economic analysis problem was formulated for demonstration.

RECENT PROGRESS

A technical memorandum describing the FY 1977 progress for this project was completed.

The preliminary results from the optimization model were analyzed. Indications are that alternative energy systems are economically feasible when energy escalation and differential inflation rates, currently recommended by the Navy, are employed.

Other progress during the report period included the completion of project planning through FY 1980.

DOCUMENTATION

"Optimization Model for Integrated Alternate Energy Systems," TM 57-78-03.

LOW ENERGY STRUCTURES

Sponsor: NAVFAC
Performer: NWC
Contact: D. Wirtz

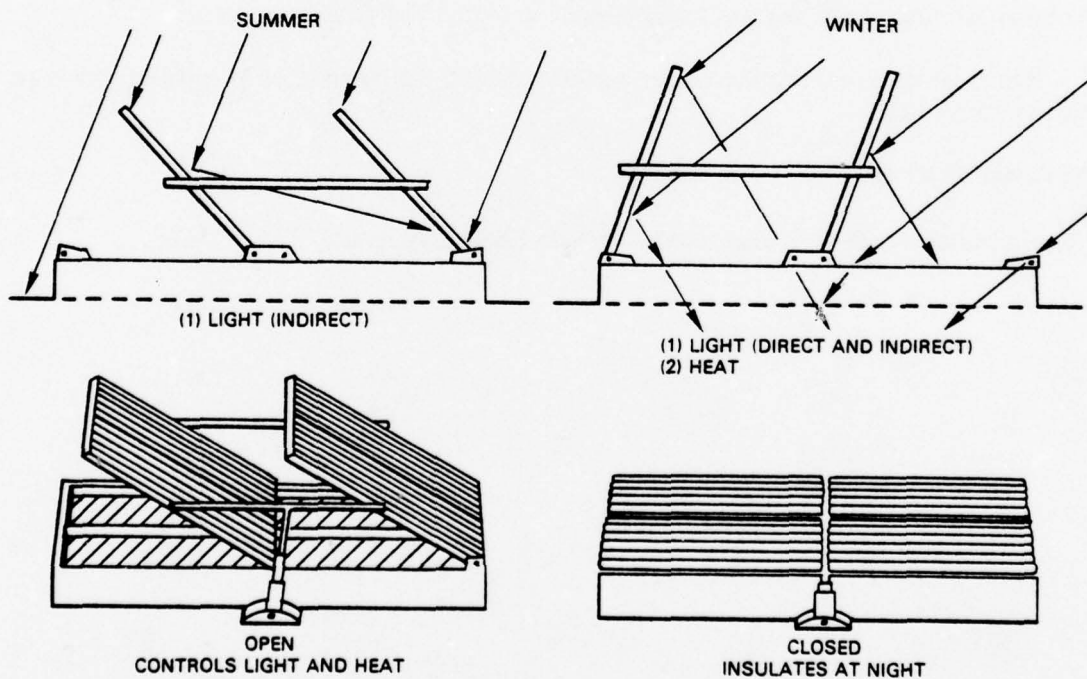
Program Element 62765N

OBJECTIVE

NWC is testing and evaluating LES concepts for new construction and retrofit applications to reduce energy consumption.

TECHNICAL APPROACH

The analytical methodology for evaluating low energy system application to structures will be developed by investigating and simplifying BLAST and other analytical heat load



LOUVERED ATRIUM CONCEPT

programs. This simple analytical aspect of the methodology will be coupled with the NAVFAC P442 type economic analysis. The test and evaluation plans are to build and test a four-louver array system for solar radiation control. A single louver will be tested to evaluate the installed R-factor (thermal resistance when closed) of a louver system.

SUMMARY OF PAST PROGRESS

NWC has been monitoring the ground temperature gradient to depths of 9 feet. Work was initiated on the experimental evaluation of the thermally insulating, radiation controlling louver concept. A test structure based on an existing ammunition magazine was designed, and construction initiated. The four foam-core, fiberglass-covered louvers, which will be used in the test facility, have been fabricated. Tests were performed on the louvers to determine their R-factor values.

RECENT PROGRESS

Construction continued on the LES test cell. The test cell will be used to demonstrate overall auxiliary energy balance, effects of high heat capacity, louver design, preconditioning of ventilation air, lighting effects, heat transfer effects through the atrium glass, plant growth in the atrium area, humidity effects, automatic louver operation, and glass coatings. Alternative LESs are being analyzed for energy conservation and retrofit potential, including potential market implementation costs, maintenance implications, and energy savings.

A motel/apartment building was selected for conversion into administrative office space incorporating LES retrofit design concepts.

DATA COMPILATION FOR ENERGY CONSUMPTION AND FACILITY OPERATIONAL STATISTICS

Sponsor: NAVFAC
Performer: CEL
Contact: R. Bergman

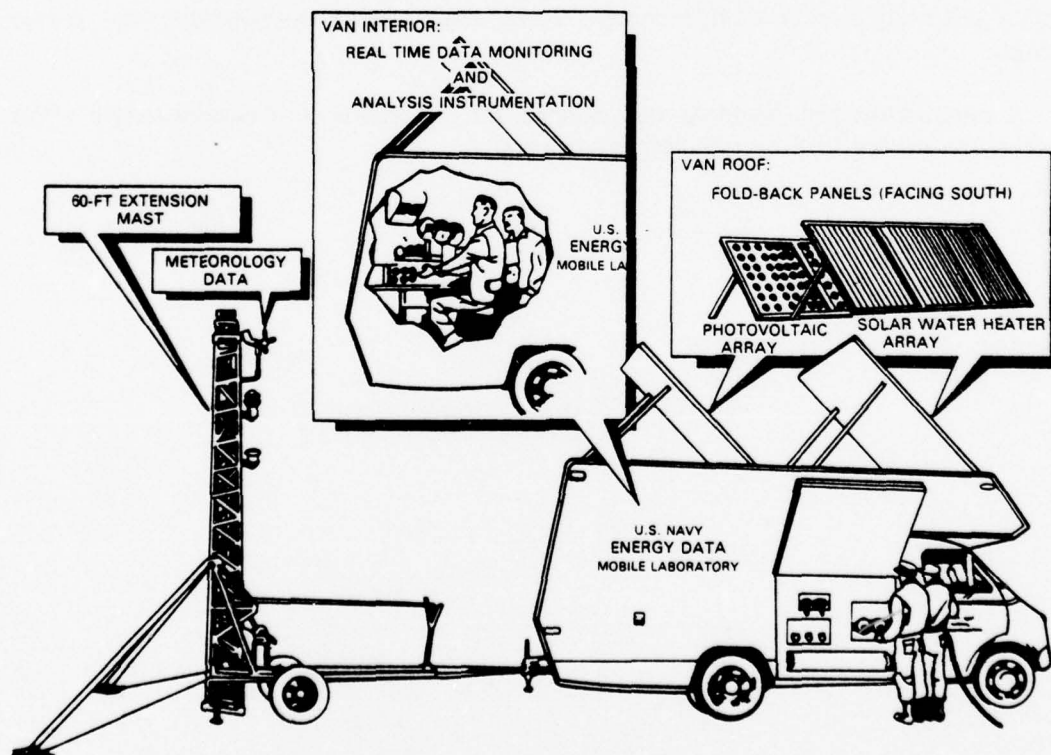
Program Element 62765N

OBJECTIVE

The objective is to compile data related to energy demand and consumption at naval installations.

TECHNICAL APPROACH

Fuel and electrical consumption data are available on a base-by-base tabulation from the DEIS-II computer program. The program contains data on consumption and cost of coal, petroleum products, electricity, steam and hot water, natural gas and propane, and liquefied petroleum gas, as well as 1973 (baseline) consumption data, by month, for each of 580 activities. These data will be analyzed and aligned by factors such as climate, geo-



ENERGY DATA MOBILE LABORATORY

graphical location, fuel transportation cost, and types of energy systems on base. The actual breakdown in energy demand by end-use category is not available from the DEIS-II program, and on-site monitoring and investigation will be required at typical Navy bases to be able to accurately estimate end-use energy consumption. The operating and maintenance cost and reliability of existing boilers, diesel engines, gas turbines, HVAC systems, and other power facilities are of importance to allow the quantitative comparison of new power system candidates with current facilities.

SUMMARY OF PAST PROGRESS

Technical Memorandum M-52-77-4, "Preliminary Report on the Estimation of End-Use of Navy Base Energy Consumption," was printed. Two different methods of estimating the end use of electrical energy at PMTC, Point Mugu, California, compared well. The simpler method could be used to obtain a Navy-wide estimate of end use, by questionnaire. End-use categories appropriate to the Navy-wide extension of this study were devised.

Space heating use and cost for over 500 separately accountable Navy activities were estimated from the FY 1976 DEIS-II. A similar estimate was made for a fewer number of activities for air conditioning energy consumption and cost. The method used for both of these estimates was essentially the same as that used for the special survey of Navy and Marine Corps family housing.

Acquisition of the EDML will increase the number of locations at which measurements can be made of the time saved in transporting instrumentation and setting up at measurement sites, as well as minimizing handling damage. The EDML is a self-sufficient, on-site, energy data gathering system capable of measuring the basic forms of energy consumption of shore structures, the energy relevant meteorological environment of those structures including total solar insolation, and processing the data for transmittal on remote demand to CEL in a computer compatible format. The EDML vehicle shell was modified for the installation of instrumentation. A 1,600-mile shakedown trip demonstrated the reliability of the vehicle.

Assistance to the PMTC, Point Mugu, California, Public Works Department Energy Officer was provided. Installation of 160 additional watt-hour meters, 36 of which have pulse generation features permitting continuous recording of electrical consumption and calculation of usage rates, was completed. Transmission will be over available telephone lines through the use of encoders, decoders, and data loggers feeding into a computer-compatible tape recording device.

All instrumentation has been checked. Field measurements using the EDML began.

RECENT PROGRESS

CEL continued to acquire, analyze, and reduce solar, wind, and other energy-related meteorological data. This included the acquisition of data on waste material production and ocean and geothermal resource data at specific Navy sites. Development of an inventory of shore activity power systems was started; performance, operation, maintenance, and

reliability information will be incorporated. The data from this project will help provide the basis for more accurate economic analyses of energy alternatives.

DOCUMENTATION

"Data Compilation for Site Characteristics of U.S. Navy Shore Installations, FY 1976,"
TM-52-66-11, September 1976.

"Data Compilation for Energy Consumption Statistics for U.S. Navy Shore Installations,
FY 1976," TM-52-76-12, September 1976.

ELECTRIC EQUIPMENT CONSERVATION

Sponsor: NAVFAC
Performer: CEL
Contact: B. Milner

Program Element 62765N

OBJECTIVE

Electrical equipment and distribution systems are being evaluated for conservation potential and for potential use in conjunction with alternative energy sources.

TECHNICAL APPROACH

The investigation will include evaluation of equipment and systems for conservation potential and for use in conjunction with alternative sources. Future studies will include laboratory and functional experiments on equipment and systems.

RECENT PROGRESS

This program began in FY 1978. The feasibility of retrofitting Navy facility air handling units with controlled torque (or Wanless) motors was analyzed. A life-cycle cost profile indicated that \$3 million could be saved annually.

COGENERATION STUDIES

Sponsor: NAVFAC
Performer: CEL
Contact: E. Cooper

Program Element 62765N

OBJECTIVE

The objective of this project is to investigate the potential of converting selected Navy bases to cogeneration and to provide background guidance for conversion.

TECHNICAL APPROACH

Several Navy bases will be examined to determine the economic payoff and the technical difficulties of installing cogeneration facilities. One base will be selected as the site for a cogeneration study.

RECENT PROGRESS

This project began in FY 1978. A survey of potential cogeneration sites indicated that more than 20 CONUS Navy bases were applicable. Jacksonville NAS/NARF was selected as the site for the cogeneration study. The statement of work for this contract study was prepared; the contract award is expected in March 1978. Utilities in the Long Beach, Alameda, and Puget Sound areas have expressed interest in Navy cogeneration projects.

Estimated energy savings are 284,000 BOE per year.

APPLICATION ENGINEERING STUDIES

Sponsor: NAVFAC
Performer: CEL
Contact: F. Herrman

Program Element 62765N

OBJECTIVE

The objective is to provide RDT&E assistance to coordinate a continuous flow of technology from national energy programs to Navy field activities and others.

TECHNICAL APPROACH

This project, the direct application of technology to activities at Navy bases, NAVFAC headquarters, and EFDs, is designed to ease the implementation of conservation devices and installation of new power systems throughout the Navy. The applications engineer is responsible for coordinating requests for RDT&E with the appropriate program personnel at CEL to fulfill the requirements of the request within CEL capabilities. CEL principal engineers in energy conservation and advanced power systems are responsible for maintaining current technology bases in their areas of expertise. Many requests for RDT&E are within the technical capabilities of the applications engineer.

Field representation is mandatory for the installation of a system at a Navy base that is under development by CEL. At least one applications engineer will be dedicated full time for the duration of the program to coordinate the solution of technical problems in the field. This effort involves important CEL interfaces with NAVFAC field activities, EFDs, the Navy Energy Office, DOE and other federal agencies, and industry.

Information on energy technology is disseminated in a wide variety of ways: overview brochures, the CEL Energy Newsletter, Techdata Sheets, progress reports to NAVFAC, detailed handbooks, and formal CEL technical memorandums, notes, and reports. Distribution of publications is controlled by NAVMAT Instruction 5720.7A; however, as wide a distribution as possible is sought for Energy Program Office documentation. The transfer of technology into the energy program for Navy bases is primarily the collective responsibility of every engineer and manager in CEL with an energy RDT&E assignment and constitutes a significant portion of their work load.

SUMMARY OF PAST PROGRESS

Contract work with Stanford Research Institute on energy conservation options at the Puget Sound Naval Shipyard was completed. The investigation identifying the effects that energy constraints would have on the shipyard's output of ship repair services, based on the yard's current functional configuration and how this configuration might be modified to conserve energy over the long term, produced some positive findings, including:

- A long-range master plan for energy conservation is needed.

- Energy metering is needed.
- The MIS should be expanded to include the type and quantity of energy that goes into providing services and manufacturing products.
- Engineering parameters dealing with heat recovery should be assessed more closely.
- A long-range management plan for electrical power is needed.
- Productivity should be improved through use of the MIS and study of industrial techniques of the more progressive shipbuilders in foreign countries.

An energy management panel consisting of personnel from Public Works, MIS and industrial shop areas was considered essential to the master plan.

A contract report by the University of California, San Diego, on energy conservation in motor-driven compressors and blowers at NRMC, San Diego, was completed. Although the results of this report will have little immediate impact on NRMC's energy consumption, information regarding the necessary measurements and techniques used to estimate motor operating efficiency and utilization will be useful for future work.

CEL selected and installed equipment at Point Mugu to record data from 36 watt-hour meters with pulse generators and transferred it to a central location. A specification to procure a computer-based energy measurement system was completed.

A summary report, which includes a procedure for evaluating heat loss and leak detection techniques used for various underground steam main configuration, was issued. Another report included an evaluation of the "Eco-Mizer" shower aerator; the aerator appears effective when used in combination with a conventional and compatible shower head such as Kohler. It effectively aerates the water spray to provide a firm shower at reduced flow rates, thus reducing the energy required to heat the water and conserving water.

Short-term wind data at Centerville Beach, California, was correlated with long-term data at Eureka, California.

A report was completed on the suitability of high-pressure sodium lighting at NARF, San Diego. The NARF color tests showed adequate color rendition and differentiation with high-pressure sodium lighting.

Thirty responses to field activities and six Energy Forum Newsletters were completed this reporting period.

RECENT PROGRESS

The report on the suitability of high-pressure sodium lighting at the NARF, San Diego, was issued. Performance and coordination of application engineering studies continued by responding to field activities and by issuing Techdata Sheets, CEL Energy Forum Newsletter articles, and other technical publications. The CEL staff continued to interface with other federal agencies and industry to facilitate technology transfer.

DOCUMENTATION

"Summary of RDT&E Energy Applications Engineering," TM M-03-77-1.

INSTRUMENTATION PACKAGES FOR FIELD SURVEYS

Sponsor: NAVFAC
Performer: CEL
Contact: J. King

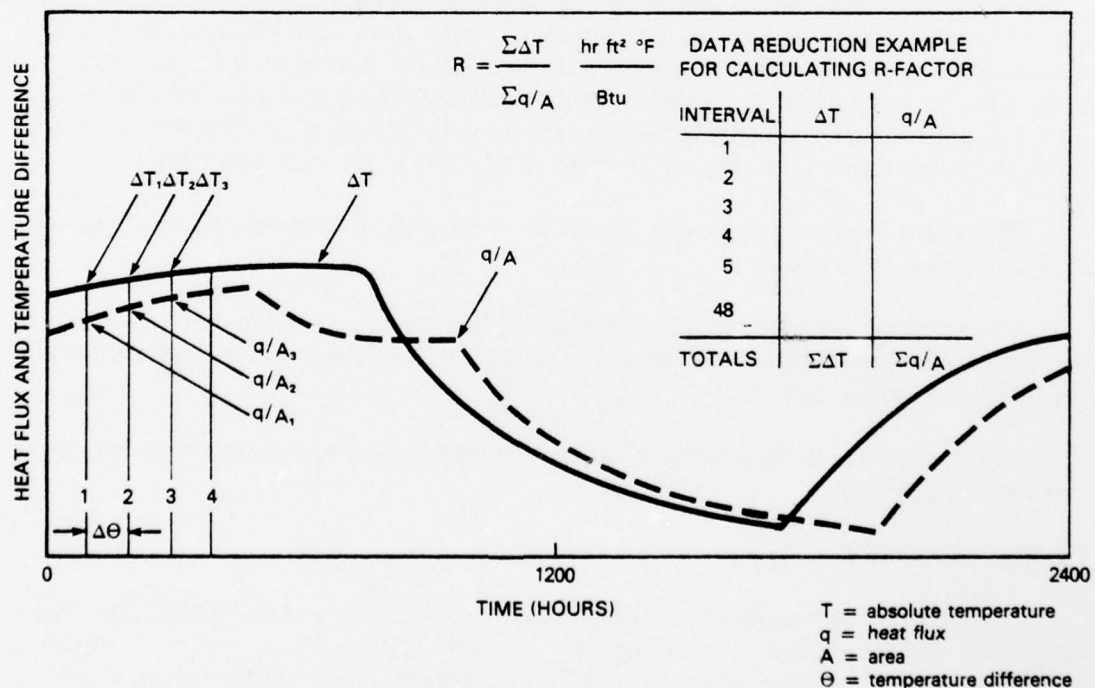
Program Element 63724N

OBJECTIVE

CEL is surveying and selecting suitable instrumentation and formulating a user's guide for conducting field surveys of energy losses for all EFDs.

TECHNICAL APPROACH

Available instrumentation will be surveyed and appropriate units procured for controlled testing. Tests will be conducted on portable infrared imaging systems, heat flux



ILLUSTRATIVE HEAT FLUX AND TEMPERATURE DIFFERENCE TRACES FOR CALCULATING R-FACTOR

meters, and associated systems. Three sets of instrumentation will be selected, procured, and checked out for field use by field survey teams. Instruments to be included in the final package will be selected based on the test results. A user's guide will be prepared based on manufacturer's instructions and data gathered during the tests. Procurement and final testing will be accomplished under engineering development.

SUMMARY OF PAST PROGRESS

All items except the infrared systems and R-factor meters for the packages were procured and checked out. Comparative cold weather field tests with the AGA 750 and the Inframetrics 510 infrared sets indicated the lower priced 510 model is satisfactory for energy loss surveys. This will permit the procurement of three packages instead of the planned two. Information for the user's report was assembled and turned over to a contractor for formulating and printing. Key contacts for the packages at the EFDs were established, and preliminary plans for training EFD personnel at CEL were made.

RECENT PROGRESS

The infrared systems and R-factor meters were received and checked out in November. This completes the receipt and check out of all items for the instrumentation packages. Work continued on the preparation of the user's manual as well as on the development of plans for training EFD personnel at CEL.

DOCUMENTATION

"The Development of Methodology for the Determination of R Values of Existing Structures by Non-Steady State Heat Transfer Measurements," CR 77.015, June 1976.

POLYURETHANE FOAM ROOFING SYSTEMS

Sponsor: NAVFAC
Performer: CEL
Contact: R. Alumbaugh

Program Element 63724N

OBJECTIVE

The objective of this project is to determine the fire safety of PUF roofing systems applied directly to a metal roof, the effects of aging on the thermal efficiency of PUF, and the optimum materials and methods for maintaining PUF roofing systems.

TECHNICAL APPROACH

Underwriter's Laboratory will conduct fire tests of PUF roofing systems that are applied directly to metal decks. Effects of aging on the thermal efficiency of insulation will be deter-

mined by measuring thermal conductivity of aged spray-applied PUF systems now in place, then comparing these values with those obtained with new PUF systems. Optimum methods for maintaining PUF roofing systems will be determined by using different methods on deteriorated and degraded PUF test panels. The energy-saving aspects of PUF roofing systems will be studied at the Roosevelt Roads Naval Station, Puerto Rico, in cooperation with NAVFAC, by monitoring energy usage before and after the application of PUF.

SUMMARY OF PAST PROGRESS

Negotiations were conducted with Underwriter's Laboratory concerning the technical aspects of the fire tests. Test panels for studying optimum maintenance methods for PUF have been built and placed in outdoor exposures at NWC, China Lake, California, as well as at Port Hueneme. Negotiations involving cooperative field studies of PUF maintenance on existing housing were conducted with NAS, Lemoore, California.

RECENT PROGRESS

The flammability and toxicity of PUF are being analyzed in four fire tests: UL790, the 25-foot tunnel, the small-scale furnace, and the 100-foot tunnel test. The purpose of the fire tests is to accumulate enough data so that UL can test the PUF. The PUF is also being tested for the effect of aging on thermal conductivity.

Estimated energy savings are 475,000 BOE per year.

LIGHTING SYSTEMS EXPERIMENTS

Sponsor: NAVFAC
Performer: CEL
Contact: W. Pierpoint

Program Element 63724N

OBJECTIVE

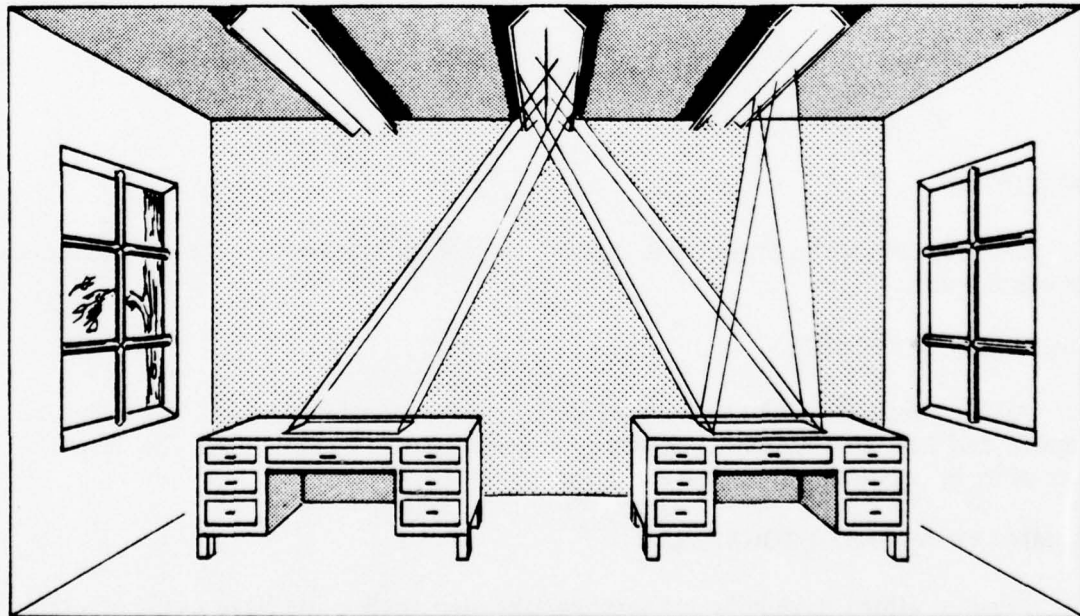
The objective of this project is to develop methods to conserve electricity in lighting while ensuring high-quality illumination.

TECHNICAL APPROACH

Meters for measuring ESI and VCP will be developed. Lighting tests will be performed to develop and evaluate task illumination furniture, multilevel ballasts, daylighting and controls. Lighting control systems will be investigated in the AEUTB. Lighting maintenance will be analyzed to determine the maximum benefit/cost.

SUMMARY OF PAST PROGRESS

A contract was awarded to develop ESI and VCP meters. The ESI meter was developed and forwarded to CEL. A patent was applied for on the concept of a microprocessor-based dimming illumination system. A solid state dimming control (for one portion of the dimming system) was developed.



LIGHTING SYSTEMS EXPERIMENT

A lighting maintenance computer program was completed. Implementation of a routine lighting maintenance program was estimated to save one-fourth of the electricity used for lighting.

An experimental task lighting system was designed and fabricated.

RECENT PROGRESS

Preparations are being made for lighting tests for simulated residential, small office, and large office systems. The lighting tests will incorporate effective use of artificial lighting to supplement natural daylighting by the use of automatic lighting controls. New energy saving lighting systems and methods, such as a maintenance scheduling computer program, for effectively implementing lighting maintenance procedures at Navy facilities continued to be evaluated.

Estimated energy savings are 540,000 BOE per year.

DOCUMENTATION

"Evaluation of Energy Saving Lamps," TM M-62-76-12, January 1977.

"Guidelines for a Lighting Maintenance Program," TN N-62-77-08, March 1977.

SEAWATER COOLING SURVEY

Sponsor: NAVFAC
Performer: CEL
Contact: J. Ciani

Program Element 63724N

OBJECTIVE

The objective of this project is to determine the Navy-wide potential of sea/lakewater air conditioning.

TECHNICAL APPROACH

All Navy facilities will be investigated to determine the economic payoff, environmental impact, and potential difficulties of using sea/lakewater air conditioning. The beneficial uses of its by-products will also be evaluated.

SUMMARY OF PAST PROGRESS

Previous efforts have indicated that sea/lakewater cooling for Navy facilities is both technically and economically feasible. From a survey, 10 candidate sites were selected for sea/lakewater cooling. Two of the key criteria for selecting these sites were that facilities had

to have access to cooling water of a sufficiently low temperature within 3.5 nautical miles of shore and that the facilities had to have a high air conditioning demand.

RECENT PROGRESS

A technical report was prepared summarizing the results of the FY 1977 work. Of the 10 candidate sites analyzed, four—Chicago, Point Mugu, Pearl Harbor, and Apra Harbor—were selected as having the most potential.

Estimated energy savings are 122,000 BOE per year.

DOCUMENTATION

“Seawater Cooling for Naval Facilities,” TM-44-76-10, August 1976.

ORGANIC RANKINE BOTTOMING CYCLE FOR DIESELS

Sponsor: NAVFAC
Performer: CEL
Contact: H. Gaberson

Program Element 64710N

OBJECTIVE

The objective of this project is to demonstrate the efficiency of a central power plant using low-temperature heat-recovery systems.

TECHNICAL APPROACH

A low-temperature heat-recovery power system (an organic Rankine bottoming cycle system) will be purchased by DOE for Navy evaluation. The system will be installed by the Navy at NAS, Bermuda, diesel-electric power plant. Data on system performance will be gathered for 3 years.

SUMMARY OF PAST PROGRESS

Navy diesel-electric power plants were surveyed to select a suitable site for this test program. Progress in Rankine bottoming cycle systems has been continually reviewed with potential system manufacturers. Communications were established between LANDIV, NAVFAC, and the Public Works Officer, NAS, Bermuda, to ensure that all special requirements will be met for the Bermuda demonstration. A technical advisory review committee comprising 12 representatives of the Navy and private industry was assembled. The goals of the program, as well as specific Navy requirements, were established by the committee.

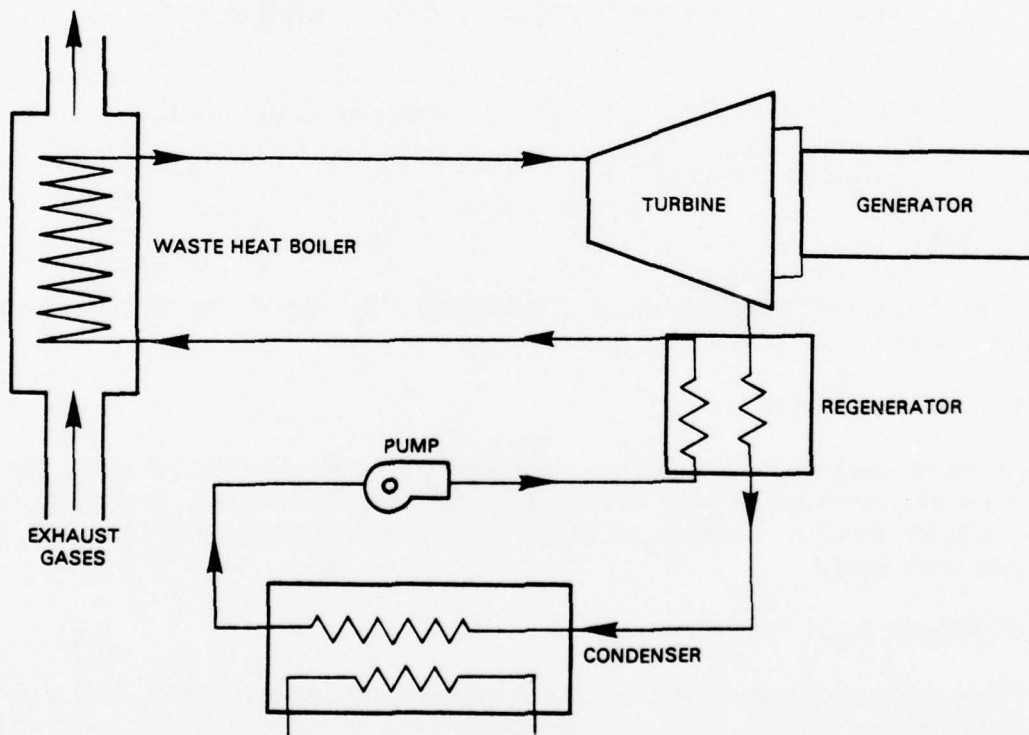
RECENT PROGRESS

The choice of equipment manufacturers was narrowed to three: Sunstrand Corporation, MTI, and Teco. The review committee began their evaluation of the three candidate systems and is expected to make its choice in the fourth quarter of 1978.

Estimated energy savings are 24,000 BOE per year.

DOCUMENTATION

"Plan for Joint Navy/ERDA Program to Demonstrate an Organic Rankine Cycle Bottoming System for a Diesel-Electric Power Plant," January 1977.



TYPICAL ORGANIC RANKINE CYCLE SYSTEM

SEAWATER COOLING FOR BUILDINGS

Sponsor: NAVFAC
Performer: CEL
Contact: J. Ciani

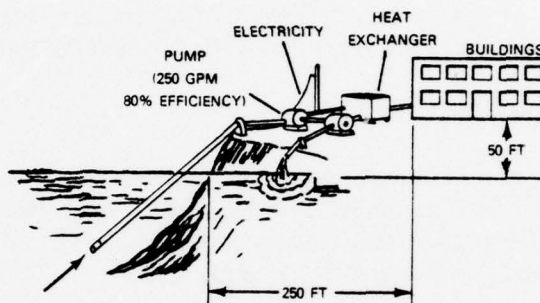
Program Element 64710N

OBJECTIVE

CEL is designing, fabricating, installing, and testing a prototype sea/lakewater cooling system at a Navy facility.

TECHNICAL APPROACH

Based on bathythermographic studies and economic analyses, a test site will be selected for the installation and testing of a sea/lakewater cooling system. The operation of the system will be monitored, and the feasibility of sea/lakewater cooling at Navy facilities will be assessed.



SEAWATER HEAT EXCHANGER

SUMMARY OF PAST PROGRESS

Previous efforts have indicated that sea/lakewater cooling for buildings at Navy coastal facilities is technically and economically feasible. In 1977, a preliminary design was made of a seawater cooling system for NSGA, Winter Harbor, Maine. Work began on seawater temperature measurements in the bay adjoining Winter Harbor and on a biofouling study of the seawater air conditioning system for this facility. In addition, land and offshore surveys were conducted in preparation for equipment installation. Preliminary energy and economic analyses, as well as environmental impact assessments, were completed and reviewed.

RECENT PROGRESS

Work continued on measuring seawater temperature, and performing land surveys, offshore surveys, and biofouling studies at Winter Harbor.

DOCUMENTATION

"Energy and Economic Analysis of the Heating, Ventilating, and Air Conditioning Systems and Modifications to the Systems to Make Them More Energy Efficient at Navy Operations Building #153, Winter Harbor, Maine," September 1977.

APPLICATION POTENTIAL OF ENERGY CONVERSION SYSTEMS

Sponsor: NAVFAC
Performer: CEL
Contact: C. Parker

Program Element 64710N

OBJECTIVE

The potential application of alternative energy systems is being assessed and a market survey conducted throughout the naval shore establishment.

TECHNICAL APPROACH

A data bank of Navy developmental system characteristics will be developed, and the systems will be applied conceptually to Navy activities. Data on electrical and thermal loads, available space, and renewable energy sources will be obtained from the site characteristics derived from related work units.

SUMMARY OF PAST PROGRESS

A work authorization was issued to determine data suitability and to recommend analytical procedures. A work statement was prepared for the main study effort.

RECENT PROGRESS

An RFP was issued to initiate the contractor selection process. Final selection is expected in March 1978.

ENERGY CONSERVATION ABOARD SHIP

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

Program Element 62765N

OBJECTIVE

The NAVSEA exploratory development program for energy conservation aboard ship is an ongoing effort to review and analyze the state-of-the-art in energy technology as it may be applied to shipboard systems. The major emphasis for this program is the reduction of fuel consumption by the future fleet through the use of alternative propulsion and auxiliary subsystems.

TECHNICAL APPROACH

The technical approach consists of several parallel efforts:

- The future nonnuclear fleet will be characterized in terms of projected ship types, powering requirements, requisite mission capabilities, and anticipated dates of fleet implementation. Projections of fleet characterization are based on the surface warfare plan, POM submissions, the extended planning annex, and extrapolations to the year 2000. Powering requirements for proposed ships and craft will be calculated based on the projected mission requirements and the anticipated displacements and hull forms.
- Propulsion and auxiliary systems alternatives will be synthesized to identify energy-related design parameters. These proposed systems will be evaluated in terms of their ability to effect minimum energy consumption and life-cycle cost while satisfying operational requirements.
- Developmental problems and risks will be identified for systems that offer the potential of minimum fuel consumption after analysis on a total-ship basis.
- Where the necessary technology base is not sufficient, exploratory development programs will be directed toward demonstrating the feasibility of pursuing hardware demonstrations. Upon realization of the potential of competing concepts, either project termination (where no advantage can be demonstrated) or graduation into advanced development will be recommended.
- Where total-ship systems analyses result in positive recommendations for implementation of systems currently in the developmental cycle, the existing program will be expedited to the extent necessary to ensure a reasonable probability of component availability relative to a projected ship construction schedule.
- Basic research and related interagency efforts will be monitored continuously to identify new concepts that offer energy conservation potential. Continuing exploratory development programs will be structured on this basis.
- In terms of changing fleet patterns, propulsion and auxiliary systems analyses will be reassessed to accommodate new machinery system requirements not foreseen in previous studies.

DTNSRDC, Annapolis, is block funded to manage the overall energy conservation aboard ship and new fuel sources effort. A considerable portion of the analytical work involved will be distributed to various other Navy organizations and qualified contractors.

SUMMARY OF PAST PROGRESS

This effort, directed at the future nonnuclear fleet, was initiated in FY 1975 with the analysis of machinery systems options for baseline gas turbine-powered destroyer and hydrofoil platforms representative of the future fleet vehicles. These analyses form the basis for projections of the energy conservation potential of the various options for future vehicles and for components and systems development under the associated advanced and engineering development efforts. When necessary, laboratory investigations have been conducted to supplement existing data.

To establish baseline characteristics that could be used to extrapolate the requirements of future ships and craft, energy-related design parameters and energy consumption characteristics of the major subsystems of destroyer and hydrofoil baselines were determined during FY 1975. Based on 1975 data, a total of 90 propulsion system and 48 ship's service electrical system alternatives were synthesized during FY 1976. These two subsystems were considered initially because the remaining shipboard auxiliary subsystems depend on the characteristics of these major subsystems. First, these were screened according to their fuel consumption characteristics over typical mission profiles. Detailed analyses, including performance, life-cycle cost, effectiveness, and developmental risk assessment, were conducted for those concepts that exhibited superior fuel consumption characteristics. Based on NAVSEA recommendations, development of a computer program was initiated to conduct life-cycle cost analyses over a realistic procurement schedule which considered logistics cost impact.

FUTURE FLEET ENERGY CONSERVATION

Project Areas	System Energy Reduction (Percent)
Hull/appendage	5-20
Propulsion	20-48
Electrical generation	5-38
Heating, ventilation, air conditioning	8-40
Lighting	20-85
Pumps	6-75

In FY 1976, the major energy users (exclusive of propulsion and electrical generation) were identified for the two baseline platforms. A program plan to analyze the energy intensiveness of major auxiliary system options was formulated. A study of destroyer lighting systems was completed in FY 1977 and several hardware areas were recommended for shipboard suitability studies and cost analyses. Analyses of the destroyer platform hydronic pumping systems were initiated in FY 1977 and preliminary investigations of HVAC systems were initiated preparatory to formulating a work statement to be issued as an RFP for detailed studies.

A contract was awarded in FY 1977 to procure a STEM. This model would allow integrated energy studies of all shipboard systems to identify optimum energy conservation arrangements on a total ship basis.

As an outgrowth of the survey and assessment studies, several specific tasks were initiated in FY 1976-FY 1977: an analysis of the response of free-turbine engines for ship's service power applications, a compilation of an energy data bank for shipboard machinery systems documentation, and a study of shipboard diesel noise and failure data.

During FY 1977, a computer model was completed and is being used to conduct detailed cost studies of energy-conserving electrical and propulsion options. Concepts meeting criteria for payback period and cumulative life-cycle savings have been recommended for further development. The study to identify shipboard diesel failures and their causes was completed and the results are being integrated with other ongoing propulsion and electrical studies. Recommendations for development of advanced propulsion and ship's service systems were made, and procurement actions and ship impact studies were initiated as advanced or engineering development tasks.

Shipboard suitability studies of lighting systems were completed, as were the associated cost analyses. Candidate lighting systems were recommended for further development.

The destroyer hydronic pumping system analyses were completed, and cost analyses of various energy-conservation options were conducted. Considerable emphasis was placed upon resolution of technological problems concerned with alternative shipboard components and systems preliminary to initiation. Hardware demonstrations under the advanced and engineering development programs will be started in FY 1978.

An RFP was prepared and issued to investigate HVAC systems. Design criteria will be reviewed, alternative HVAC configurations will be synthesized and analyzed, and cost and effective data will be collected.

The STEM contract was initiated; the resulting computer program will be installed on DTNSRDC's CDC 6700 computer, and a series of validating test cases will be exercised. A library of component data is being developed to serve as baseline reference data for the STEM. A study of energy storage systems potentially compatible with shipboard requirements was initiated, and the results will be integrated into the STEM component library.

The future fleet is being characterized in terms of ship type and powering requirements to provide mechanisms for scaling the baseline results to projected future ship types and to allow establishment of developmental priorities.

RECENT PROGRESS

A study was initiated to establish the feasibility of the main propulsion system to provide ship's service electrical power for the baseline platform. Costs analyses were completed on high intensity discharge lamps and solid state high-frequency ballasts. A decision was made to pursue these hardware programs under advanced development. Investigations were begun to establish energy conservation pump/piping system design criteria and to identify the energy payoff associated with large-diameter pipe. A task to identify the energy saving potential and cost-effectiveness of high-efficiency electric motors was initiated. Formulation of methodologies to incorporate energy conservation in all aspects of new ship design was begun and is being applied to the emerging CVV and FFG(X) platforms. A computer program to analyze operation and performance of a generalized steam turbine was completed and is being integrated with the STEM.

DOCUMENTATION

"Summary of FF-1052 Class Frigate Energy Conservation Program," Report 1825-03-03, October 1977.

ADVANCED SHIP COMPONENTS

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

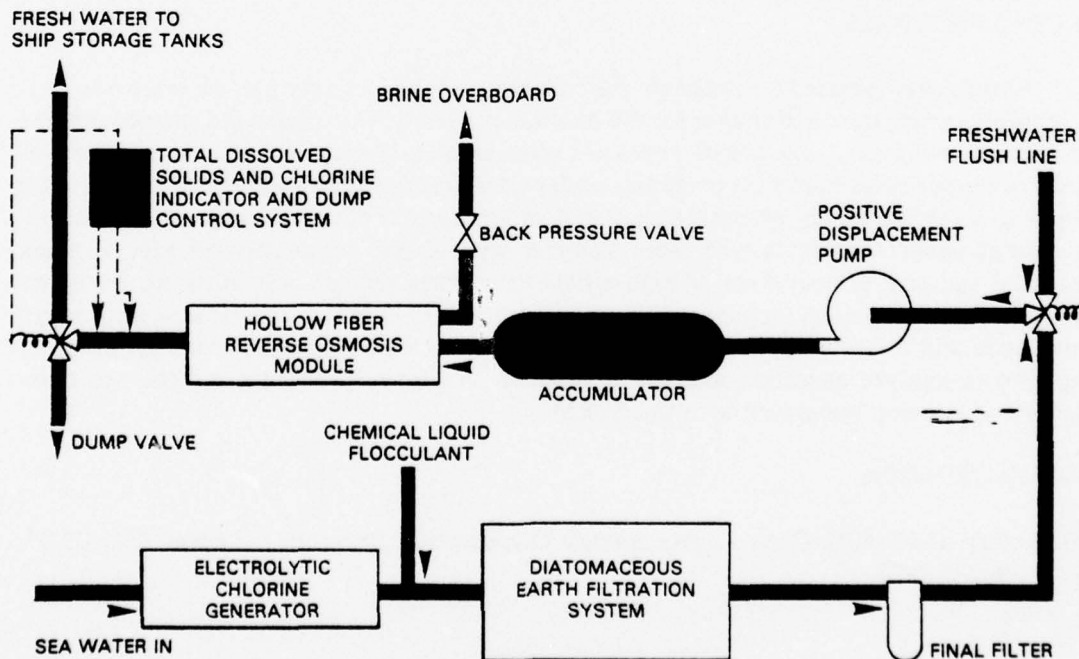
Program Element 63724N

OBJECTIVE

The objective is to conduct model tests and hardware demonstrations of machinery systems and components that have the potential to reduce fuel consumption through improved efficiency without reducing the effectiveness and mission capability of future non-nuclear ships and craft. The goal is to prove the advantages to be gained through the application of a new technology, as well as to define additional development necessary before beginning the engineering development program.

TECHNICAL APPROACH

When an advanced development program is recommended that does not involve an effort currently in the development cycle or an effort that does not come within the purview



2,000-GALLON-PER-DAY REVERSE OSMOSIS DESALINATION SYSTEM

of another NAVSEA program office, the Energy R&D Office will propose to lead the development. This is the most direct form of participation, and those subsystems or systems qualifying for this type of advanced development support would continue through the developmental cycle, leading to fleet implementation. Efforts during this phase could be conducted entirely within Navy laboratories, but in most cases would require contractor participation.

When a developmental program is identified that is not already in the development cycle but does come within the scope of an existing NAVSEA program office, the Energy R&D Office will lead the effort by providing funding and design criteria. When an effort already in the developmental cycle as an existing NAVSEA program could benefit from additional support, the Energy R&D Office will participate by providing supplemental funding and continuing analyses of energy-related design parameters.

When the technology assessment conducted as part of the exploratory development phase indicates that there is a significant energy-saving potential associated with a developmental program that is well established and fully funded under an unrelated program element, the Energy R&D Office will encourage progress without participating. The Energy R&D Office will provide the responsible program manager estimates of the energy conservation potential of the development and will provide continuing analyses to assess the merit of the development of alternate applications.

When technology appears to have possible merit for naval application but is being developed by another agency for an unrelated application, the Energy R&D Office may elect to monitor the program. In this case, the Navy would merely indicate a possible future interest in the subsystem or system development.

The specific tasks currently under way or planned for initiation in FY 1978 as a part of this project are reverse osmosis desalination, diesel noise analysis, HVAC systems, advanced pumping systems, lighting systems, and free turbine ship's service generator.

SUMMARY OF PAST PROGRESS

Reverse Osmosis Desalination

The component development program included work on improved ultra filtration, improved membrane technology, and high-efficiency, high-pressure brine pumps in support of reverse osmosis. The objectives were to provide potable water at an energy savings of 70 to 80 percent for steam ships and to dedicate waste heat on gas turbine vessels to HVAC rather than distillation.

Diesel Noise Analysis

This effort involved the use of diesel engines as cruise (base) engines on gas turbine combatants. Significant fuel savings are expected, but noise requirements for ASW combatants is of concern. This work has concentrated on stability criteria of the diesel engines in an attempt to exploit the efficiency advantages offered at certain ship speeds.

HVAC Systems

A contract was awarded to Garrett AiResearch to begin analysis of shipboard HVAC systems.

Advanced Pumping Systems

The objective of this program is to evaluate alternative pumping systems as potential replacements for insufficient pumps. Alternatives considered include different devices, pump types, operating procedures, and configurations. The evaluation has concentrated on the seawater service and firemain systems, but spin-offs for all other systems are being considered where appropriate.

Lighting Systems

The development of solid state high-frequency ballasts was approved and effort to conduct this work in conjunction with a similar DOE program were initiated. Initial tasks will be continued with characterization performance degradation at elevated ambient temperature, electromagnetic interface problems, and the sensitivity of return on investment to acquisition cost.

Free Turbine Ship's Service Generator

This work element will begin in FY 1978.

RECENT PROGRESS

Reverse Osmosis Desalination

A prototype reverse osmosis plant was designed, built, and laboratory tested. Shipboard testing and operations of a prototype 2,000-gallon-per-day reverse osmosis plant was initiated aboard the Monob (YAG-61).

Diesel Noise Analysis

A propulsion fuel consumption/cost analysis was completed. A CODOG noise analysis was initiated.

HVAC Systems

This project will be started in FY 1978.

Advanced Pumping Systems

A destroyer system performance analysis was completed.

Lighting Systems

This project will be started in FY 1978.

DOCUMENTATION

"Advanced Ship Pumping Systems Data Collection and Analysis," J. J. Henry, April 1977.

BIOFOULING PREVENTION AND REMOVAL

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

Program Element 63724N

OBJECTIVE

The objective of this program is to initially reduce and ultimately eliminate the fuel consumption penalties associated with the accretion of biofouling on ship hulls, propellers, and sonar domes. This fouling constitutes the single largest inefficiency associated with underway operations.

TECHNICAL APPROACH

Improved underwater hull cleaning techniques; biofouling protection systems; and hull, sonar dome, and propeller coatings will be developed, and associated laboratory analyses will be conducted.

Biofouling Protection Systems

Ultrasonic devices of different frequencies, intensities, and configurations will be tested to determine their effectiveness for protecting sea chest materials and components against fouling. A biofouling protection system will ensure that the efficiency of shipboard propulsion and machinery systems is not compromised by reduced heat exchanger effectiveness or cooling water flow. Commercially available systems as well as hardware developed at the Naval Coastal Systems Laboratory will be used.

Hull Cleaning

The basic approach of the hull cleaning program is to determine how and when to conduct in-situ cleaning of hull, sonar dome, and propeller surfaces. As part of this effort, current hull cleaning technologies will be surveyed and candidate methods selected for shipboard trials. The candidate cleaning methods will be evaluated, by laboratory and field investigations, on the basis of availability, cleaning effectiveness, and compatibility with paint

systems. The cost-effective time interval between successive cleaning operations will be determined by conducting shipboard trials to measure the fuel penalty/fouling relationship as a function of time out of drydock and since last cleaning. Recommendations will be made based on the results from laboratory and field investigations. The laboratory development of improved cleaning techniques will continue with emphasis on reducing the labor intensiveness of present diver-deployed methods.

Hull Coatings

The laboratory development, test, and evaluation of OMP paints, previously conducted under project 64710N, Z0371, is now under this project. OMP paints formulated for use on ship hulls will be laboratory tested for compliance with current military specifications and environmental safety as well as the ability to keep ship hulls fouling free for 5 to 7 years without cleaning. Special application coatings designed for use on propellers, sonar domes, and intakes will be developed by chemically altering commercially available and laboratory synthesized polyurethane and epoxy resins to incorporate OMP antifoulants, and by laboratory testing the performance of the coatings, under conditions designed to simulate actual propeller, sonar dome, and intake operations. Both the OMP paints for ship hulls and special application coatings will be tested for compliance with current military paint specifications and evaluated through patch-panel immersion tests. Enough paint of the most promising polymers will be procured to conduct shipboard evaluations in the engineering development program.

SUMMARY OF PAST PROGRESS

Biofouling Protection Systems

The driver units for all tests were fabricated, and transducers of various frequencies developed.

The beam patterns and acoustic intensity for laboratory test transducers irradiating through steel plates were measured before installing the transducers for field tests. Frequency effectiveness tests were started.

Hull Cleaning

Candidate underwater hull cleaning techniques were evaluated from a hardware and operational viewpoint. Both diver-operated hand-held rotary brushes and semiautomatic hull cleaning devices were investigated.

A state-of-the-art survey of underwater applied paints was conducted to assess their applicability for repairing hull paint damage between regular overhauls.

A program was initiated to evaluate techniques, including jets, for cleaning recessed areas and sea chests. A program was also initiated to determine the "scrubbability" and refouling rate of aged antifouling paints.

Hull Coatings

In work on hull coatings, 150 OMP resins were synthesized; four resins remained fouling-free for 5 years; five contracts for coating formulations were awarded and over 40 coatings were received. Volatility, leach rate, and acute toxicology studies on OMPs 1, 2, and 5 were completed, and an environmental impact assessment was prepared. BUMED approved the coatings and authorized the application of belly stripes to light ships; NAVSEA applied the belly stripes.

Military specification tests on coatings were conducted. Static immersion tests and special application coating development were started. In addition, large-batch polymers were procured and OMP 4 was reformulated.

RECENT PROGRESS

Biofouling Protection Systems

Minor repairs and component upgrade were completed during the winter when biofouling growth was at a minimum. Laboratory tests continued with certain species of growth and specific ultrasonic frequencies. The intent is to establish optimum frequency ranges for growth prevention. In other work, flat-plate transducers were immersed in algae- and barnacle-seeded aquariums in an attempt to define the actual mechanisms of ultrasonics that inhibit growth.

Hull Cleaning

"Brush boat" cleaning of the U.S.S. Morris Shields was monitored and has undergone preliminary evaluation. Sea chest fouling and growth accumulation has been documented, and the data are being used as a baseline for jet cleaning studies scheduled for FY 1978. Eight different types of brushes were evaluated on fouled surfaces. Brushes best suited for specific tasks were identified. An additional 72 test panels are being tested at various sites to characterize site-specific types of fouling. Propeller cleaning methods were evaluated, with emphasis on reducing surface wear.

Hull Coatings

Recent progress is reported in the engineering development program.

DOCUMENTATION

"Submarine Hull Cleaning/Trials Plan," November 1977.

IMPROVED HULL AND APPENDAGE DESIGN

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

Program Element 63724N

OBJECTIVE

The objective of this project is to identify existing and/or verify new designs of ship appendages, hulls, and propulsors that may reduce power loss or increase propulsive efficiencies of nonnuclear surface combatants, thus improving their energy conservation.

TECHNICAL APPROACH

Candidate designs for naval ship hulls, appendages, and propulsors are being evaluated in laboratory model tests to identify those most likely to improve efficiency. Included in this effort are detailed literature surveys and data base reviews on powering requirements.

RECENT PROGRESS

A DD 963 class model was built with the stern section modified to fit novel stern appendages, and several stern models were built to determine the effect of transom stern variation on drag. Perry class frigates were evaluated to define improvements that might lead to new reduced drag hulls for incorporation into new class frigates. Candidate propulsor concepts that promise the greatest potential for improved energy conservation were also evaluated.

FUEL OIL STRIPPING

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

Program Element 64710N

OBJECTIVE

The objective of this program is to determine how much usable fuel is lost because of shipboard fuel tank stripping and to recommend solutions to reclaim the fuel for shipboard use.

TECHNICAL APPROACH

Ships for engineering analysis will be selected. Attention will be given to ship classes and propulsion systems that consume significant quantities of energy. Ship records will be

retrieved in the analysis and will concentrate on fuel management and previous stripping evolutions. Stripping concentrations will be analyzed using gross underway sampling.

RECENT PROGRESS

This program will begin in FY 1978.

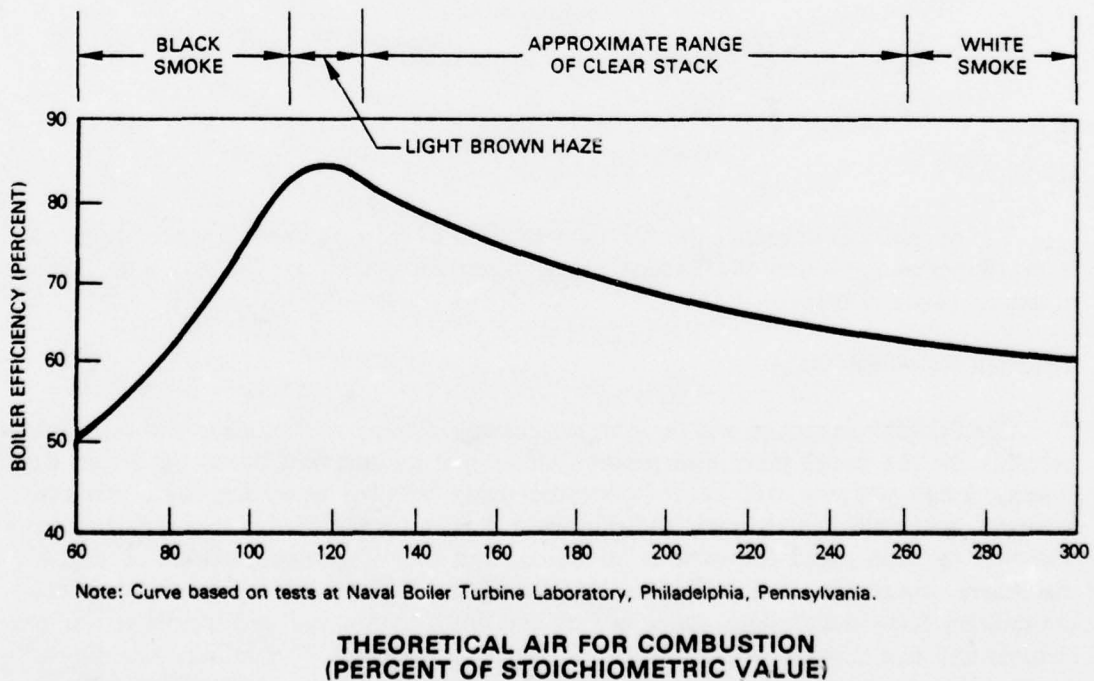
STACK GAS ANALYZER

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

Program Element 64710N

OBJECTIVE

A fully automatic combustion control system based on the oxygen analysis principle is being developed. The system will maintain boiler combustion air at peak efficiency during all conditions of demand, and will result in a 7 to 15 percent reduction in fuel consumption on major ship classes. (Present techniques are inadequate for optimum combustion control using current distillate fuels.)



TECHNICAL APPROACH

Based on laboratory and shipboard experience with oxygen analysis, a specification will be prepared to procure two analyzer systems for use on 1,200 psi plants. This procurement will be based on in-situ analyzers and extraction techniques.

SUMMARY OF PAST PROGRESS

Laboratory instruments were evaluated on shipboard and shore-based boilers. A procurement specification and program plan for test and evaluation were prepared.

RECENT PROGRESS

Competing shore-based systems were analyzed, and laboratory investigations and shipboard trials of laboratory systems were completed. NAVSEA has been tasked to procure two shipboard systems. These systems will be developed during FY 1978. Operation evaluation will be initiated during the first quarter of FY 1979.

Estimated energy savings are payback of 4,100,000 BOE by 1980.

MACHINERY OPTIMIZATION

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

Program Element 64710N

OBJECTIVE

The objective is to reduce the fuel consumption of existing steam-powered ships by at least 10 percent through the use of energy-intensive machinery systems and efficient operating procedures.

TECHNICAL APPROACH

The FF 1052 class ships will be analyzed initially. Energy consumption and distribution patterns for the boiler plant and steam systems will be analyzed based on design data. Energy usage patterns will be corroborated using detailed operating logs, instruction manuals, past empirical analyses, and ship visits. Realistic quantified energy utilization profiles will be determined for various missions, total steaming hours, effects of degraded machinery conditions, and individual operational preferences. Based on these analyses, preliminary recommendations supported by cost information will be formulated for procedures and equipment modifications to effect energy savings. Preliminary recommendations will be subjected to sensitivity analyses to determine feasibility, cost-effectiveness, and applicability.

NSRDC and contractor personnel will conduct a series of underway measurements to verify the estimates made in the analyses. Sea trials will be conducted in two phases: Phase I trials will be conducted at various speeds and under normal operating conditions to represent typical underway fuel consumption rates; Phase II trials will be conducted under controlled conditions to determine the amount by which fuel consumption can be reduced as a result of improved operating procedures. Recommendations will be forwarded to NAVSEA for consideration for fleetwide implementation. The methodology will be documented so that it can be used to extend the analyses to other ship classes.

The identification of energy-intensive machinery systems will lead to recommendations for minor and major equipment and procedural modifications based on the cost-effectiveness of the modification when amortized over the remaining operating life of the ship. Minor equipment modifications are those that can be accomplished without restricting the availability of the ship. Major equipment modifications are those that have to be done during ship overhaul. Procedural modifications refer to changes in existing machinery operating practices that can be done without lessening the degrees of operational readiness.

SUMMARY OF PAST PROGRESS

Heat-balance analyses based on design data, technical documentation, previous sea trials, and certification data of a demonstration ship were completed for the FF 1052 class. The analyses were performed by adapting a MARAD computer program to the FF 1052 class steam cycle. Power plant operating characteristics and fuel consumption were determined for the mission profile (8 knots to full power) in 2-knot increments.

A sea-trial plan was developed, and the instrumentation needed to quantitatively verify energy usage profiles at various steaming conditions was identified. Phase I and II trials were conducted 27 September through 2 October 1976 on the U.S.S. Holt (FF 1074). Phase I

trials involved normal steaming power at various speeds with machinery aligned in accordance with standard operating procedures. Phase II trials involved steaming at the same power levels as Phase I, but with boiler excess air maintained at 15 to 20 percent, one ship service turbine generator on-line, one forced

draft blower per boiler, standby main feed pumps taken off-line, and all pressures and temperatures set according to design conditions. For each phase, flow rates, shaft torque, boiler excess air, condenser vacuum, and subsystem temperatures and pressures were measured at each speed. Results indicated that the fuel consumption rate in Phase II was significantly lower than the fuel consumption rate in Phase I, particularly in the cruising range of the ship. Phase II fuel consumption was 16.7 percent lower at 12 knots and 10.6 percent lower at 16 knots. Heat-balance calculations were completed and a final report was prepared detailing recommendations for energy-conserving equipment and procedural modifications.

Methodology was developed to extend the FF 1052 class analyses to other ship classes, and a trials plan was developed for follow-on cruiser/destroyer steam plants.

SEA TRIAL RATES

At anchor	One boiler operation
8 knots	One boiler operation
12 knots	One boiler operation
16 knots	One boiler operation
20 knots	One boiler operation
20 knots	Two boiler operation
24 knots	Two boiler operation
Maximum sustainable power	Two boiler operation

Sensitivity analyses were conducted for the FF 1052 class recommendations of electrically driven or cold-start, turbine-driven, standby main feed pumps; waste heat feedwater heater; and anchor power diesel generator set.

RECENT PROGRESS

In the first quarter of FY 1978, the FF 1052 class energy usage survey results were piled and a revised balance baseline was assembled based on this survey. The retrieval of the U.S.S. Holt was postponed until the second and third quarters of FY 1978.

The FF 1052 steam-cycle computer program was changed to allow for interchangeability and degradation of system components and for modifications to the steam cycle.

Cost, size, weight, and performance data for a cold-start turbine (TERRY) being used as a main feed pump drive were collected. Cost factors for retrofit are being considered. The same data as for the TERRY turbine are being considered for an electrically driven main feed pump.

A significant result of the machinery optimization program was the conclusion that ship performance under different machinery and operational variables must be monitored continually. Thus, a performance monitoring program was initiated.

Estimated energy savings are 6,007 barrels per year per ship.

DOCUMENTATION

"Machinery Optimization Post-Overhaul Trial Plan for U.S.S. Holt (FF 1074)," Report 1825-01-02, August 1977.

PERFORMANCE MONITORING

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

Program Element 64710N

OBJECTIVE

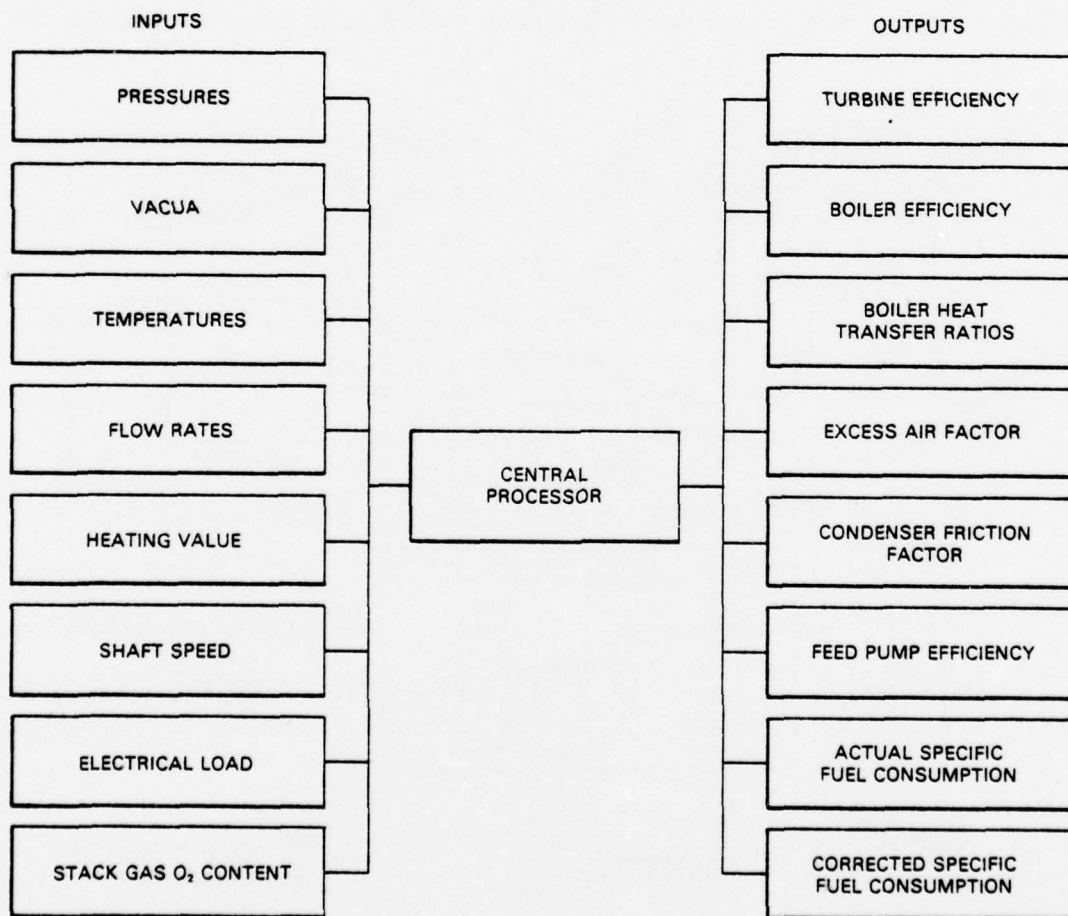
The objective is to provide ship engineering officers with diagnostic information on hull and power plant condition, thereby enabling immediate rectification of the effects of system malfunction/degradation and elimination of increased fuel consumption.

TECHNICAL APPROACH

NAVSEA will define the causes (such as design deficiencies, operator error, necessary maintenance, or system/component degradation) of nonoptimum operations aboard ship. From these determinations, performance monitoring is expected to provide an indication of deviation from optimum system heat balance, provide a quantitative basis for timely correction, promote a means for comparing different operating modes, and quantify before and after effects of remedial actions.

RECENT PROGRESS

This project began in FY 1978. Basic planning for system acquisition and trials was done. This work has included initiating procurement of a performance monitoring system, developing plans for modification of the system for Navy use, and developing trial guidelines for heat balance.



MACHINERY PERFORMANCE MONITORING INTERFACE

WATER RESOURCES MANAGEMENT

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

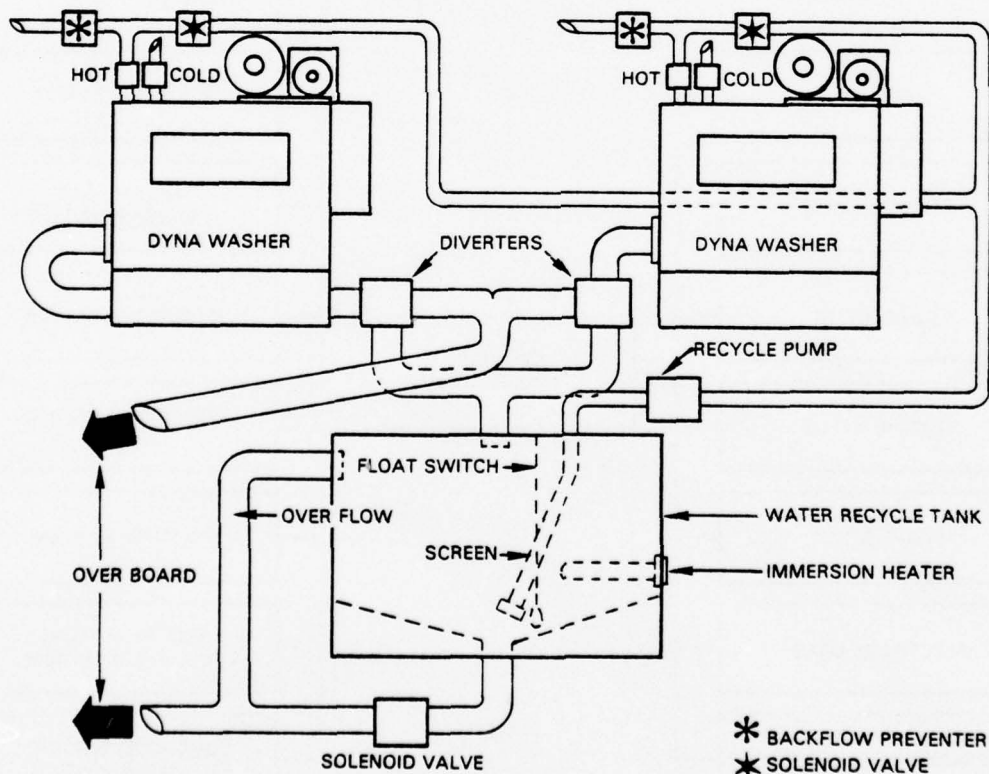
Program Element 64710N

OBJECTIVE

DTNSRDC is identifying freshwater flow patterns aboard ship and formulating water resource management techniques to improve the efficiency of freshwater production and utilization aboard ship.

TECHNICAL APPROACH

Existing processes, operations, and activities consuming fresh water will be analyzed on an FF 1052 class frigate and an aircraft carrier. The areas where water use reduction is possible will be identified and impact assessed. After identifying potential payoff areas, studies



LAUNDRY RINSE WATER REUSE SYSTEM

will be conducted leading to recommendations for specific equipment and procedural modifications. These proposed modifications will then be subjected to at-sea evaluation and their effectiveness measured.

SUMMARY OF PAST PROGRESS

Shipboard freshwater usage patterns identified by an existing water pollution data base were extended to determine detailed energy use. Further determination will be made through the installation of 100 water flow meters on the U.S.S. Saratoga (CV 60) and 25 water flow meters on the U.S.S. McCandless (FF 1084). Flow meter installation has been completed.

A plan for testing and evaluating a commercially available laundry water recycling system was completed. In initial tests, laundry water was cleaned and recycled 50 times, reducing consumption of fresh water 88 percent and chemicals 50 percent. The detailed laboratory investigation was completed.

Candidate waste treatment systems were analyzed to determine the cost of freshwater production. A life-cycle cost analysis was completed and the results of the total waste recycle system were summarized.

RECENT PROGRESS

Measurement with 30 potable water flow meters were made on U.S.S. Saratoga during a 6-month deployment. Several meters malfunctioned and data transmission ceased. The at-sea tests are being rescheduled.

Trade-off analysis of competing laundry water recovery systems identified the rinse water recovery/reuse system as the most cost-effective. The Navy Clothing Textile Research Facility is evaluating the effectiveness of the system.

Alternative approaches to saving water are being evaluated. These concepts utilize new detergents and procedures to save water and time.

Use of hand held, reduced flow, shower heads is being studied. Initial results indicate a much higher operation or acceptance than with fixed, reduced flow, shower heads.

Studies were initiated for improved procedures and automated shutdown and lightoff for ship evaporators.

Estimated energy savings are 474,000 BOE per year by 1980.

HULL COATINGS

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

Program Element 64710N

OBJECTIVE

The objective is to test improved hull coatings at sea. (This task provides engineering development for the hull coatings work of the NAVSEA conservation effort.)

TECHNICAL APPROACH

OMP-based paints will be synthesized from previously synthesized OMP resins. The OMP-based paints will undergo laboratory tests for compliance with current military specifications. Small batch formulations are being procured for patch-panel static immersion tests and shipboard application evaluation. Up to 20 ships will have waterline-to-keel belly stripes applied with the OMP-based paints while drydocked as part of the normal overhaul schedule. The coatings will be monitored to determine their antifouling performance.

Special application coatings designed for use on propellers and sonar domes will be developed by chemically altering commercially available and laboratory-synthesized polyurethane and epoxy resins to incorporate OMP antifoulants. Once synthesized into paints, these coatings will be laboratory tested for compliance with current military paint specifications and will be evaluated for antifouling effectiveness through patch-panel static immersion tests. If acceptable, sufficient paint quantities will then be procured to conduct shipboard evaluation.

SUMMARY OF PAST PROGRESS

Of the 150 OMP resins that were synthesized, four have shown satisfactory antifouling characteristics through 5 years of patch-panel immersion tests. These are the base materials for the small-batch formulation of improved antifouling paints for shipboard evaluations. Shipboard evaluations were started in 1976. Laboratory tests and evaluation of special application antifouling paints for use on propellers and sonar domes have been under way and will be continued in the advanced development program in FY 1978.

RECENT PROGRESS

Candidate OMP hull coatings for initial ship trials were evaluated. All combinations of OMP compositions were acceptable as coatings over all primers that were tested. The number of coats that was required to accomplish a 4 mil thickness was determined for each composition. The cure time between coats was also determined.

Other characteristics of OMP hull coatings, such as brushability and rollability, were evaluated. After 6-month immersion tests at Miami, Florida, and Pearl Harbor, Hawaii, four candidate coatings were selected for ship application.

Twenty samples of propeller coatings were laboratory tested. Six were identified as satisfactory and four, marginally satisfactory. Fifteen samples remain to be tested.

Formulation of ship trial plans was started.

HULL CLEANING

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

Program Element 64710N

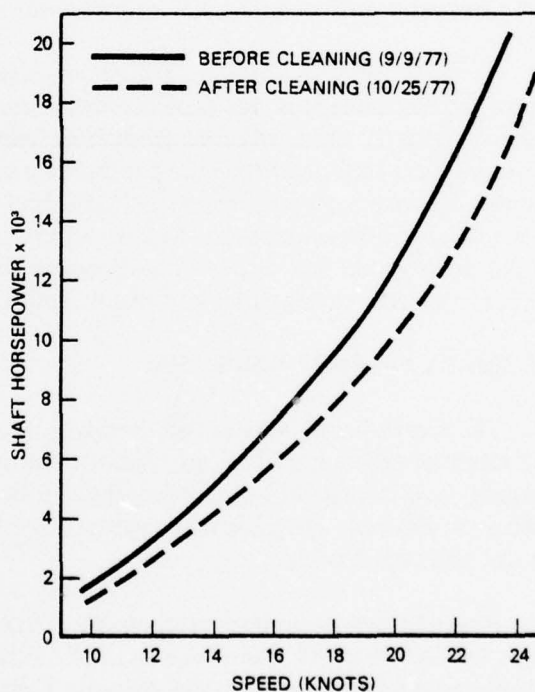
OBJECTIVE

The objective is to provide for sea trials to determine acceptable hull cleaning techniques and to determine the most cost-effective cleaning frequency. (This task provides engineering development for the hull cleaning work of the NAVSEA conservation effort.)

TECHNICAL APPROACH

The FF 1052 class was selected for the hull cleaning program primarily because its mission profile is representative of that of the largest number of Navy ships and because a minimum of instrumentation is required.

Trials will be conducted in two phases. Phase I involves pier-side instrumentation, hull cleaning, and underway testing of a large number of Navy ships immediately before routine dry-docking so that cleaning effectiveness can be evaluated. Phase I is designed to answer the question of how to clean hulls, as a function of both the state of fouling and the method to be used in cleaning. As part of the routine drydocking and overhaul schedule, up



SHAFT HORSEPOWER VERSUS SHIP SPEED
U.S.S. STEIN

to 15 ships will undergo selected underwater cleaning. Upon drydocking, shortly after cleaning, the effectiveness of the cleaning method will be evaluated and any detrimental effect on the paint system documented.

Phase I of the trials plan is a 2-year evaluation to determine the cost-effectiveness of the underwater cleaning techniques. Instrumentation to measure speed and shaft horsepower will be installed on four ships for 2 years. The effects of fouling will be monitored at convenient times during the ships' deployments.

Short power trials are routinely scheduled at about 30-day intervals, and the collected data forwarded to DTNSRDC for analysis. When the power required for a given ship speed increases above a predetermined value, DTNSRDC personnel will assist in conducting a detailed power trial aboard the test ship. Underwater cleaning of the test ship will then be done and a postcleaning power trial conducted to assess the effects of cleaning. Reference and test ship power levels will be compared during the 2-year test period. This approach should give a realistic estimate of the relative fuel and cost savings that can result from regular underwater hull cleaning.

Based on results from the laboratory and field studies, fleet implementation guidelines for underwater hull cleaning will be prepared and issued.

The hull cleaning program will be conducted as a controlled experiment. An exacting controlled experiment is not possible with commissioned ships; however, a reference ship and a "cleaned" ship, selected from both the Atlantic and Pacific fleets, will be tested through Phase II to determine the comparable effect of fuel savings with scheduled frequent cleaning against fuel requirements without hull cleaning for a 2-year test period. Each pair of test ships will be selected on the basis of identical class, similar mission requirements, and similar deployment schedules. This approach should provide a realistic basis for estimating the fuel and cost savings that can result from regular hull cleaning.

SUMMARY OF PAST PROGRESS

The rotary-brush cleaning method was selected for evaluation as a result of a survey of hull cleaning technology and the "how to clean" demonstrations done in 1976. Two commercially available rotary-brush cleaning systems—Scamp and Brush Kart—were chosen for testing. A sea-trials program was approved, and instrumentation was selected and procured for the shipboard trials.

Phase I trials were conducted on the U.S.S. Holt (FF 1074) during May and June 1976. Ships for the Phase II trials were selected: U.S.S. Trippe as the reference ship and U.S.S. Blakely as the test ship from the Atlantic Fleet, and U.S.S. Whipple as the reference ship and U.S.S. Stein as the test ship from the Pacific Fleet.

An evaluation of the Sperry Doppler ship's speed sensor to ascertain repeatability and accuracy was initiated as part of the sea-trials effort. A new sensor that can be installed from within the ship was designed and fabricated. This sensor will reduce the complexity and trial time required.

RECENT PROGRESS

Analysis of ship trial data continued. DTNSRDC gathered and analyzed data on the effect of fouling and cleaning on ship horsepower versus RPM and shell pressure versus RPM. Further analysis indicated that the concept of test and reference ship for comparison was difficult because of variations in operating patterns.

In November 1978, Phase II trial underwater hull documentation photographs were consolidated into charts, the U.S.S. Whipple conducted a minitrial, and the U.S.S. Trippe and U.S.S. Blakely were documented for fouling growth. The U.S.S. Blakely conducted initial power trials and was cleaned and documented in December. Among other activities, the doppler log system deficiencies were corrected, a Ribikoff underwater color television camera was tested at DTNSRDC for possible use on the hull cleaning documentation program, the first draft of a review of underwater applied coatings was submitted, and a state-of-the-art report on waterborne submarine hull cleaning and the SIMA survey was started.

Estimated energy savings are 3,500,000 BOE per year.

2,000 kW QUIET DIESEL GENERATOR

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

Program Element 64710N

OBJECTIVE

The objective is to procure, test, and evaluate a quiet diesel generator set suitable for installation on ASW combatants.

TECHNICAL APPROACH

The noise reduction requirements will be determined for diesel engines utilized as prime movers for electrical generators. The state-of-the-art of noise isolation techniques will also be determined. An RFP will be prepared for procurement of a quiet diesel generator, test and evaluation will be performed, and recommendations for fleet implementation will be made. This effort is an outgrowth of survey and assessment studies made under 62765N.

SUMMARY OF PAST PROGRESS

A program plan and preliminary noise analysis were completed.

RECENT PROGRESS

A comprehensive noise analysis to define in detail the various noise isolation package options and their trade-offs was initiated.

SHIPBOARD COMBUSTION SYSTEM IMPROVEMENTS

Sponsor: NAVSEA
Performer: DTNSRDC
Contact: C. Krolick

Program Element 64710N

OBJECTIVE

This project is designed to improve the efficiency of shipboard propulsion systems by reducing the excess boiler air requirements from 15 percent to 5 percent.

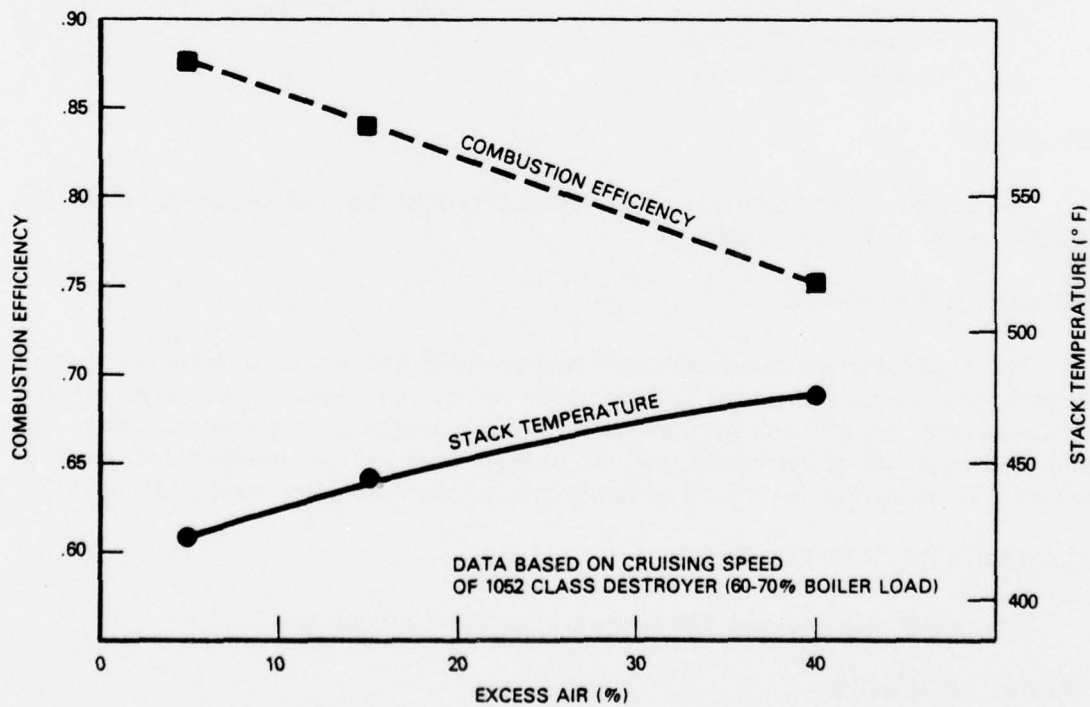
TECHNICAL APPROACH

Commercial systems that reduce excess air in ship boilers are available. This project will study the capability to adapt such a system for use on Navy ships. Of concern in the testing will be the ship performance under part load conditions using 5 percent excess air.

RECENT PROGRESS

This project will begin in FY 1978.

Estimated energy savings are 2,370,000 BOE per year.



BOILER PERFORMANCE VERSUS EXCESS AIR

AIRCRAFT FUEL CONSERVATION

Sponsor: NAVAIR
Performer: NADC
Contact: C. Lampart

Program Element 62765N

OBJECTIVE

NADC is investigating and identifying ways to conserve energy during the operation of current inventory Navy aircraft. The goal is to identify potential technology applications, operational alternatives, or both, which could save energy.

TECHNICAL APPROACH

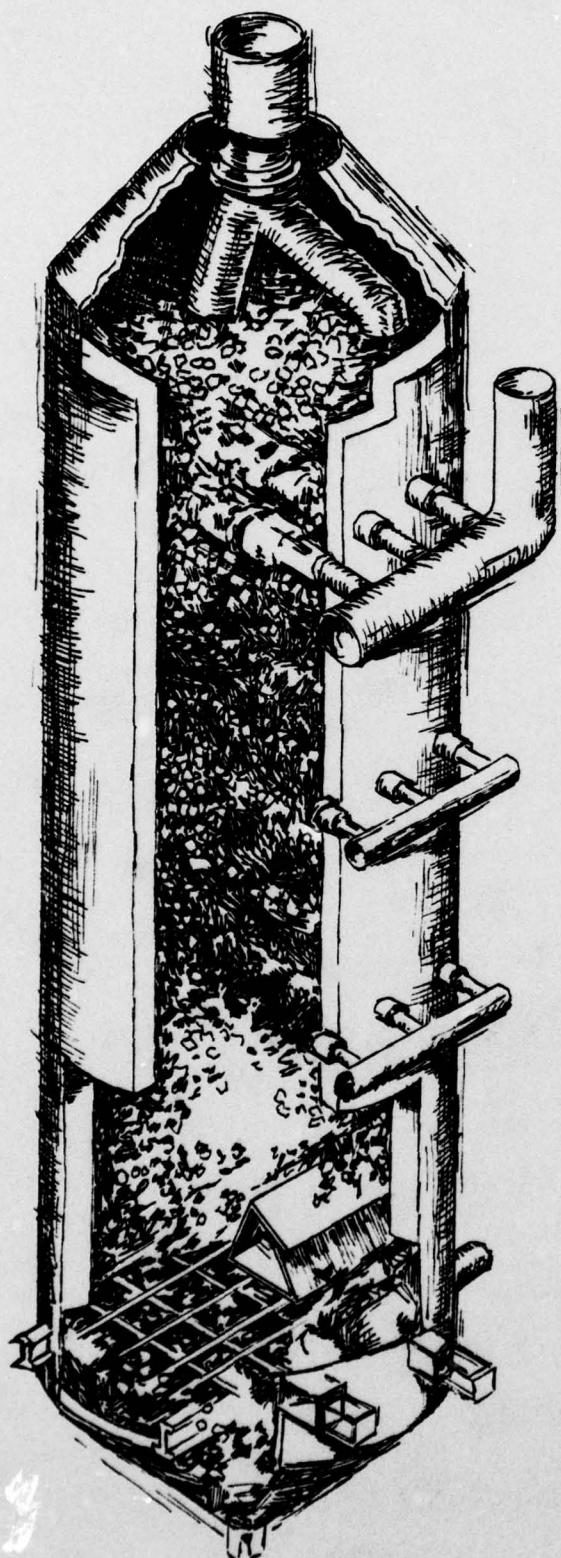
Selected Navy aircraft will be studied to analyze the effects on fuel usage of potential "advanced technology" design changes in aerodynamics, airframe, propulsion, etc. The studies will be followed by an in-house Navy analysis of the impact of applying these proposed energy saving modifications on the performance and cost of the selected aircraft.

Mission/functional analyses will be done to identify alternative operational tactics and/or payloads (sensors, weapons) that could result in energy savings. Potential differences in mission effectiveness resulting from applying the identified fuel saving tactics or changing payloads will be evaluated.

RECENT PROGRESS

This project began in FY 1978. The six Navy and Marine aircraft types that used 75 percent of the Navy's aircraft fuel during 1976 were identified. These aircraft types are F-4, P-3, A-4, A-6, A-7, and F-14. Conservation efforts will concentrate on these six aircraft types.

The mission/function analyses of the six aircraft types began during January 1978. The purpose is to determine the effects of payloads, tactics, mission profiles, mission planning, and training procedures on fuel usage and mission effectiveness; identify promising fuel saving techniques; and identify the impact of fuel saving techniques on fuel usage, system costs, schedules, performance, and system effectiveness.



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SYNTHETIC FUELS

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Performer: DTNSRDC/A	

AIRCRAFT FUEL CHARACTERIZATION ANALYSES

Sponsor: NAVAIR
Performer: NAPC/NRL
Contact: C. Nowack

Program Element 62765N

OBJECTIVE

The objective is to evaluate the chemical and physical suitability of synthetic and broadened specification conventional fuels for use in aircraft propulsion systems.

TECHNICAL APPROACH

The physical and chemical characteristics of synthetic- and petroleum-derived, and nonspecification aviation fuels will be determined and compared with those of military specification fuels. Distinctive characteristics of these fuels, along with possible safety, handling, compatibility, and performance problems, will be determined.

SUMMARY OF PAST PROGRESS

The characteristics of coal-derived fuels were found to deviate slightly from those required in current specifications. These differences, however, did not affect performance of the coal-derived fuel in a small engine test or of the fuel handling equipment. Most of the off-specification properties could be corrected by costly refining procedures that are not normally used when processing petroleum into JP-5.

A Canadian (Athabasca) tar sands JP-5 was found to meet all the specification requirements, and its performance in small engine and fuel handling tests was equivalent to that of petroleum JP-5.

The thermal stability of an oil-shale-derived JP-5 was found to be unacceptable because of the type of organic nitrogen compounds in the fuel. The effects of accelerated storage on this fuel demonstrated the need for oxidation inhibitors. The unacceptable freeze point of this fuel was found to be largely due to the high concentration of n-hexadecane. The combustion products resulting from a large burning pool of an oil shale JP-5 revealed that the concentration of benzo(a) pyrene was equal to or less than that in petroleum JP-5. Work with fuel decontamination equipment revealed that a shale oil JP-5 degraded the performance of a water coalescer. Despite the gross contamination and instability of this particular oil shale JP-5, engine performance was satisfactory. High oxides of nitrogen were found in the exhaust because of fuel-bound nitrogen. Most of the fuel deficiencies, such as thermal instability and the presence of gums, were corrected by postrefining techniques performed in the laboratory.

RECENT PROGRESS

The basic nitrogen compounds in oil shale fuels were identified as predominantly alkyl pyridines. Studies of the effects of microbiological contaminants on fuel systems were started.

Laboratory studies on the use of DFM as an emergency aviation fuel are in progress. The data indicate that the use of DFM in the neat form is prohibitive because of the high freezing point and low thermal oxidation stability. DFM blended to a concentration of 10 and 20 percent with JP-5 still exhibits properties that are not within the current specification.

The design of a low-temperature environmental unit and standard laboratory control test equipment to study fuel pumpability at low temperatures is under way. Studies have been initiated under contract to evaluate combustor performance on a spectrum of fuels (alternate and broad specification fuels and DFM) using a T63 combustor.

A TF30-P-408 fuel system test with oil shale JP-5 was completed. Test results showed that the performance of the oil shale fuel was equivalent to that of a petroleum JP-5. A post-test teardown inspection of the test equipment showed corrosion in some of the critical areas of the fuel control system. This corrosion is believed to be caused by the fuel-bound nitrogen compounds.

A T63 engine exhaust emission test was performed with blends of petroleum and oil shale JP-5 fuels. The conversion rate of fuel-bound nitrogen to oxides of nitrogen was about 45 percent.

SYNTHETIC FUELS LABORATORY TEST PROGRAM

Sponsor: NAVFAC
Performer: CEL
Contact: T. Fu

Program Element 62765N

OBJECTIVE

The physical and chemical characteristics of synthetic residuals and fuel oils are being evaluated and compared with those of conventional fuels.

TECHNICAL APPROACH

CEL will characterize and analyze synthetic fuel samples to determine if they can be used in land-based power systems. The potential hazards associated with the use of synthetic fuels, as they apply to personnel, equipment, and the environment, will also be evaluated.

SUMMARY OF PAST PROGRESS

The open-flame test facility was used to study burning characteristics of the synthetic fuels (residuals) from shale. Synthetic heavy fuel oil was fired in a 30-horsepower firetube boiler.

Open-air-burner firing tests were conducted using heavy fuel oil with acoustic and steam atomization nozzles. Analysis of radiation heat-flux measurements indicated that, at a particular fuel firing rate, the heat flux was 43 percent greater using the synthetic heavy fuel oil from shale than it was using conventional No. 5 burner oil.

Preparation of a handbook of technical data on nonspecification fuels in Navy boilers was started.

Results of turbulator tests in an operational boiler showed that stack-gas temperature was reduced and boiler efficiency increased. Up to 30 percent waste fuel was blended into clean fuel and fired successfully in conventional oil burners, and up to 60 percent waste JP-5 was blended with No. 2 fuel oil and fired successfully.

RECENT PROGRESS

Storage and handling tests and small boiler firing tests were completed. Waste jet fuel/fresh oil blends of up to 60 percent jet fuel were fired successfully. Blends (up to 30 percent) of waste ship fuel, however, presented burner problems, possibly caused by bilge accumulations in the waste oil.

NEW ENERGY SOURCES/NEW FUEL SOURCES

Sponsor: NAVSEA
Performer: DTNSRDC/A
Contact: C. Krolick

Program Element 62765N

OBJECTIVE

The objective is to develop the necessary technology to reduce fleet dependence on foreign and domestic petroleum resources by using synthetic fossil fuels. The goal is to determine, through laboratory analyses of the basic properties of syncrudes and synthetic fuels, the suitability of using these fuels in Navy weapons platforms.

TECHNICAL APPROACH

Synthetic fuel products will be screened in military specification tests and physical and chemical property analyses. On the basis of these screening tests, fuels that appear to offer

significant potential will be tested in small- and large-scale engines in advanced development programs and sea trials in engineering development programs. In addition to operational fuel considerations, assay analyses will determine potential sources of other synthetic products (lubricants, hydraulic fluids, etc.) of interest to the Navy.

Aside from synthetic fuels derived from coal, oil shale, and tar sands, fuels derived from other chemical synthesis and conversion processes will also be investigated for potential Navy use.

Laboratory analyses will include DFM military specification tests of synthetic fuel samples. If the results are favorable, candidate fuels will be characterized further by physical and chemical properties. If a particular synthetic fuel appears suitable, it will be recommended for further test and evaluation under the advanced development program. If, however, the fuel is unsuitable, upgrading studies may be performed so that the manufacturer can be informed of the deficiencies in the product and the additional refinements required before the product can satisfy Navy requirements. Should the fuel show no potential, it will be eliminated from consideration.

Other laboratory tests will include crude assay analyses of various synthetic crudes to determine their potential distillate yield and quality. These analyses are conducted in cooperation with DOE and other DOD laboratories.

SUMMARY OF PAST PROGRESS

Crude assay analyses, characterization studies, and upgrading investigations of 21 samples (12 synthetic fuels, 3 synthetic crudes, and 6 other synthetic products) have been completed. Of the samples, 6 were derived from tar sands and the remainder from coal and shale oil. The samples were characterized on the basis of fuel specification tests and physical and chemical property analyses. Assay analyses were performed on the synthetic crudes to determine their potential distillate yields and quality as military fuels. In addition, upgrading studies were conducted on some of the synthetic fuels.

RECENT PROGRESS

Further work on this project will be done when synthetic fuel from the 100,000 barrel shale oil program is delivered. Delivery is scheduled for early FY 1979.

SMALL-SCALE AIRCRAFT ENGINE TESTING WITH SYNTHETIC FUELS

Sponsor: NAVAIR
Performer: NAPC
Contact: L. Maggetti

Program Element 63724N

OBJECTIVE

The objective is to determine the effects of using synthetic JP-5 derived from coal, shale oil, and tar sands. Using small-scale engines and components minimizes the cost of test hardware, test facilities, equipment, and operation and maintenance of test hardware.

TECHNICAL APPROACH

Based on the results of laboratory investigations conducted under the exploratory development program, full-scale engine tests will be conducted on the TF-34 and TF-30 engines using synthetic JP-5 fuel derived from coal, shale oil, and tar sands.

SUMMARY OF PAST PROGRESS

A TF-34 engine test using JP-5 derived from shale oil was run for 30.9 hours. This engine test program was conducted using the general acceptance and qualification tests of MIL-E-5007D, October 1973. Engine performance at sea-level conditions and at altitude was equivalent to the performance of JP-5 petroleum-derived fuel.

RECENT PROGRESS

Further work on this project will be done when synthetic fuel from the 100,000 barrel shale oil program is delivered. Delivery is scheduled for early FY 1979.

COAL UTILIZATION SYSTEMS—CENTRAL COAL-GASIFICATION PLANT

Sponsor: NAVFAC
Performer: CEL
Contact: D. Williams

Program Element 63724N

OBJECTIVE

CEL is evaluating the technical and economic feasibility of a central coal-gasification plant that removes sulfur and particulates from the fuel gas. The production of a clean fuel gas would permit the use of existing oil- and gas-fired boilers, as well as existing steam distribution systems. The expected cost of synthetic pipeline quality gas will be determined for use in Navy fuel cost projections.

TECHNICAL APPROACH

A preliminary design, cost estimate, and site selection feasibility study was conducted for a central gasification plant. Two contracts for the background work were awarded. One,

funded for FY 1976 and FY 1977, is for a preliminary design and parametric analysis of two types of coal gasifiers. The other, funded for FY 1977, is for a site-specific feasibility study to be performed at three or more Navy bases that have been directed to convert to coal. The immediate payback will be to save existing oil through use of gas-fired boilers and steam distribution systems.

SUMMARY OF PAST PROGRESS

The energy production requirements for the plant were determined to be 2,500 million Btu per day; coal use, 200 tons per day; and energy in the gas, 185 to 300 Btu per cubic foot.

The contract for preliminary design and parametric analysis was awarded to the Bechtel Corporation, San Francisco, California, and was completed in June 1977.

RECENT PROGRESS

The final report is being prepared.

SMALL-SCALE TESTS WITH SYNTHETIC FUELS FOR FACILITIES

Sponsor: NAVFAC
Performer: CEL
Contact: T. Fu

Program Element 63724N

OBJECTIVE

Synthetic fuels are being tested in small-scale components to determine their acceptability for use in Navy shore facility boiler plants.

TECHNICAL APPROACH

Performance tests with small-scale components will include pollution emission measurements. Preliminary systems tests will be done using existing 200-horsepower boilers and auxiliary equipment. The possibility of modifying existing shore-based boilers to accommodate synthetic fuels (residuals) will be studied if other approaches to utilize synfuels fail.

SUMMARY OF PAST PROGRESS

A 300-horsepower (20,000 pounds per hour) PWC utility boiler at NCBC was fired using 15,000 gallons of synthetic heavy fuel oil from the 10,000 barrel oil-shale experiment. The emission of nitrogen oxides was about three times higher than federal standards allow. Other than the high emission of nitrogen oxides and the high pour point, the synthetic heavy fuel oil was superior to conventional No. 5 burner oil.

RECENT PROGRESS

Instruments for measuring stack-gas emissions were installed on a 200-horsepower boiler. Multiple fuel storage, metering, and transfer systems were also completed, and boiler shakedown tests conducted. The facility is now fully operational. Approximately 10,000 gallons of residual shale oil are on hand for testing.

LIGHT REFINED LIQUID FUELS FOR SHIPS

Sponsor: NAVSEA
Performer: DTNSRDC/A
Contact: C. Krolick

Program Element 63724N

OBJECTIVE

The objectives of this project are to:

- Assess the suitability of synthetic fuels for shipboard use.
- Assess the feasibility of relaxing and/or modifying current military fuel specifications to increase the availability and decrease the cost of conventional shipboard fuels.
- Assess the suitability of synthetic fuels for shipboard use through small- and full-scale engine tests.
- Develop a computer based synthetic fuels data bank.

In conjunction with the exploratory development project, the test results from this project will contribute to the overall Navy synthetic fuels goal of ensuring the continued availability of hydrocarbon fuels for fleet operational use. In response to the DOD objective to modify federal and military fuel specifications to allow greater use of nonpetroleum-based fuels, this program will also examine the feasibility of implementing synthetic shipboard fuels in FY 1980 and beyond.

TECHNICAL APPROACH

Subject to the characterization analyses conducted under the exploratory development phase, candidate fuels will be evaluated in marine boilers, diesels, and gas turbines, and in associated shipboard fuel system components.

Candidate synthetic fuels will be screened on the basis of their performance in small-scale test rigs. Initial boiler evaluations will be based on tests conducted with a single-burner test rig, and diesel engine evaluations will be based on tests conducted with small-scale (one- and three-cylinder) diesel test engines. Gas-turbine engine evaluations will be based on tests conducted with a single-can combustor (for the DDA501K17) and an annular combustor

(for the FT-9 and LM2500) test rigs. If, on the basis of the small-scale engine and laboratory test results, a particular synthetic fuel remains a feasible candidate for fleet operational use, it will be recommended for full-scale engine test and evaluation. The tests will use generic engines representative of the major populations of boilers, diesels, and gas turbines currently used or proposed for use in the fleet.

The compatibility of the candidate fuels with the fuel system components associated with the engine (pumps, filters, injectors, etc.) will be assessed. In addition, laboratory investigations will be directed toward assessing the total impact on the Navy fuel logistic system, from supplier to user, of using synthetic fuels. Areas of consideration include logistics and handling requirements, potential fire and safety hazards, and potential personnel health hazards. Personnel health hazards tests will be conducted in cooperation with BUMED and other health-effects agencies.

A computerized data-handling system will be developed to support the various synthetic fuels tests and evaluation programs. In addition to providing a centralized system for the storage and retrieval of experimental data for both conventional and synthetic fuels, this system will be designed to support various comparison and correlation studies.

In the area of shipboard fuels flexibility, the feasibility of adopting a multifuel capability will be assessed. If there are cost and availability advantages to using fuels that cannot be procured under current military specifications, a determination will be made as to the degree and nature of the fuel flexibility that could be permitted without compromising fleet operational performance.

In the final phase of the program, all test results obtained for a particular synthetic fuel will be reviewed. If judged acceptable, fleet implementation guidelines, including necessary revisions to existing military fuel specifications and the establishment of special-use requirements, will be developed.

SUMMARY OF PAST PROGRESS

System compatibility and special logistics and handling needs were analyzed, and a semiempirical technique based on shipboard and laboratory measurement was developed to predict shipboard exposure levels of potentially toxic compounds resulting from using synthetic fuels. An investigation of the effectiveness of present fire-fighting agents and techniques in extinguishing synthetic fuel fires was started.

DFM derived from Paraho shale oil was tested in a single-burner boiler, a three-cylinder diesel, and an NTCC-350 six-cylinder diesel engine. Its performance compared favorably with that of standard DFM.

Contracts for gas turbine tests using DFM derived from oil shale were awarded to Detroit Diesel; Allison, Pratt and Whitney; and General Electric. Results were reported in "Compilation of Oil Shale Test Results."

Preliminary results of the fuel flexibility/availability study indicated that:

- Use of nonspecification conventional fuels may be advantageous under certain conditions, for example, when military specification fuels are not available and nonspecification fuels can be used without compromising safety or performance.
- Shortages of JP-5 have occurred, and the situation will be aggravated should the other Services switch from JP-4 to JP-8 and by the introduction of heavy Alaskan crudes.
- If the flash point of shipboard fuels were lowered 4°F to 6°F, fuel availability could be increased significantly.

A draft of a computerized system for processing synthetic fuels data was nearly completed. Thus far, the computer storage/retrieval program and initial data correlation program have been completed.

In the synfuels toxicology projects, a 12-point sampling system for monitoring the concentration of fuel vapors in shipboard compartments was developed. Atmospheric studies in the fire and engine rooms and around auxiliary machinery aboard U.S.S. Hewes (FF 1078) were completed. An in-house evaluation of a thermal desorption unit, a portable gas chromatograph, and sorbent media for hydrocarbon vapors was started.

RECENT PROGRESS

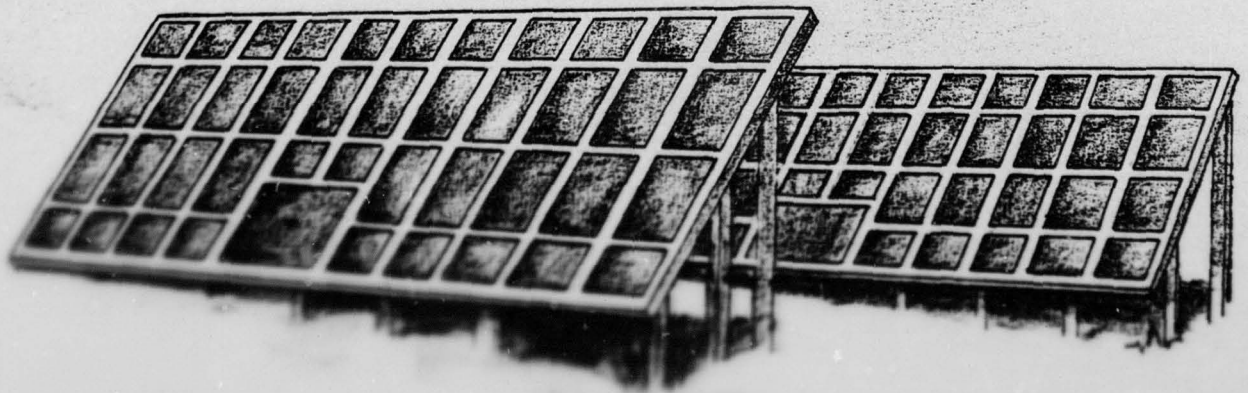
Atmospheric surveys aboard U.S.S. Talbot (FFG-4), U.S.S. Saratoga (CV-60), and U.S.S. Elliot (DD-967) were completed and total hydrocarbon measurements from conventional and synthetic DFM were made. Shipboard compartments were surveyed for suspended particulate matter, sulfur dioxide, nitrogen dioxide, and carbon monoxide. Atmospheric contaminants were within threshold values set by BUMED.

Three-month inhalation studies of conventional JP-5 were initiated in October 1977, and of conventional DFM in December 1977.

DOCUMENTATION

"Alternate Petroleum Based Fuels for Naval Fleet Usage: Potential Availability, Cost, and System Impact," June 1977.

SELF-SUFFICIENCY



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NAVY GEOTHERMAL SITE ASSESSMENT

Sponsor: NAVFAC
Performer: NWC
Contact: R. Fulmer and
C. Austin

Program Element 62765N

OBJECTIVE

All Navy sites are being surveyed to determine which have potential for geothermal resources and, through geologic interpretation and evaluation, the order in which the sites should be explored.

TECHNICAL APPROACH

The geothermal potential of Navy bases throughout the world will be judged on the basis of their proximity to areas of high seismicity and geologically recent volcanic activity. Those installations having appropriate land resources and geothermal potential will then be evaluated through literature search and analysis and, in some cases, field evaluation. Results will be used to rank the locations with respect to their geothermal potential. This will provide the principal input for detailed geological/geophysical studies.

SUMMARY OF PAST PROGRESS

Navy geothermal sites were identified and plotted in relationship to worldwide seismic/volcanic activity. A contract was awarded to Dr. James Whelan of the University of Utah to conduct the literature search and assist in the geologic evaluation of the Navy sites. The Air Force also became interested in having a similar survey made of their installations and tasked NWC to expand the Navy survey to include Air Force installations. Guam was the first Navy installation examined. Although no surface manifestations are present and the volcanics are generally older than considered favorable for a good geothermal heat source, Guam still has some geothermal potential.

RECENT PROGRESS

A significant number of Navy and Air Force sites were evaluated based on searches of the geologic literature. Memorandums were written on results. Naval sites of particular interest are Hawthorne, Nevada; Pagan, Marianas Island; Fallon, Nevada; and Adak, Alaska. The contract with Dr. Whelan was extended until 30 December 1977. Results of the individual studies will be compiled into a single report documenting the study.

DOCUMENTATION

"Geothermal Potential of Guam, Marianas Islands," J. Whelan, CDR CEC USNR (informal working paper).

"Geothermal Potential of Military Bases in Puerto Rico," J. Whelan.

- "Geothermal Potential of NAF Sigonella, Sicily," J. Whelan, August 1977.
- "Geothermal Potential of Saipan, Marianas Islands, J. Whelan.
- "Geothermal Potential of Incirlik Air Base, Turkey," J. Whelan, March 1977.
- "Report of the Geothermal Energy Possibilities of the Ankora Air Station, Ankora, Turkey," W. Daniel.
- "Report of the Geothermal Resources at Cligi Air Base, Izmir, Turkey," W. Daniel.
- "Geothermal Potential of Major Military Installations in Japan," W. Daniel.
- "Geothermal Potential of Yap Islands, Caroline Islands," J. Whelan.
- "Geothermal Potential of Truk Islands, Caroline Islands," J. Whelan.
- "Geothermal Potential of Tinian, Marianas Islands," J. Whelan.
- "Geothermal Potential of Naval Facility at Naples, Italy," J. Whelan, March 1977.
- "Preliminary Report, Geothermal Potential of Lajes Air Force Base, Terceira Island, Azores," J. Hyde and J. Whelan, April 1977.
- "Geothermal Potential of the Naval Ammunition Depot, Hawthorne, Nevada," J. Whelan.
- "Geothermal Potential of the Military Facilities in the Gulf Coast Area," W. Brumbaugh and J. Whelan, April 1977.
- "Geothermal Potential of Military Bases in Florida," J. Whelan.
- "Final Report, Geothermal Potential of Mountain Home Air Force Base and Saylor Creek Air Force Range, Idaho," J. Hyde and J. Whelan.
- "Preliminary Report on the Geothermal Potential of Military Bases in Colorado," C. Danielson, September 1977.
- "Geothermal Potential of Shemya Island, Alaska," J. Whelan, September 1977.
- "Geothermal Potential of Military Bases in Nebraska," J. Whelan.
- "Geothermal Potential of Ellsworth Air Force Base, South Dakota," J. Hyde and J. Whelan, April 1977.

GEOTHERMAL IMPACT ON NAVY MISSIONS

Sponsor: NAVFAC
 Performer: NWC
 Contact: R. Fulmer and
 C. Austin

Program Element 62765N

OBJECTIVE

The objective of this project is to identify and document the impact of geothermal exploration, development, and utilization on the basic missions of Navy shore facilities.

TECHNICAL APPROACH

Functions basic to geothermal exploration, development, and exploitation will be examined relative to a list of characteristic Navy missions. Both harmful and beneficial impacts resulting from such geothermal activities on or adjacent to Navy land will be identified and documented in a form suitable for use in Navy and DOD facilities contemplating use of this alternative energy resource.

SUMMARY OF PAST PROGRESS

Navy missions and geothermal exploration, development, and utilization functions were characterized.

RECENT PROGRESS

A report on geothermal impacts on Navy missions was written and is being reviewed. A report on the development of geothermal resources at and around NWC is being prepared.

GEOHERMAL LEGAL AND INSTITUTIONAL STUDIES

Sponsor: NAVFAC
Performer: NWC
Contact: R. Fulmer

Program Element 62765N

OBJECTIVE

NWC is identifying and exploring the institutional, legal, and operational interface considerations that exist in the exploration, development, and exploitation of geothermal resources on and adjacent to Navy property, and is providing guidelines to the Navy on the use and management of such resources.

TECHNICAL APPROACH

The legal and institutional problems facing the Navy if it develops any geothermal resources on or adjacent to Navy property will be identified and categorized. Each problem will be examined in detail through a study of existing regulations, statutes, court decisions, or precedents. The Navy position will then be defined and, where appropriate, legal alternatives provided. Where needed, a course of action will be recommended to clarify and resolve those problems for which present legal knowledge does not provide answers.

SUMMARY OF PAST PROGRESS

Legal and institutional problems were identified and the processes of resolution initiated. Many problems were identified based on actual Navy experiences at NWC,

Lualualei, and Adak. Scenarios were developed for a variety of possible situations where Navy geothermal, legal, and land disposition experts foresaw possible conflicts. Ramifications of the legal and institutional problems identified were explored and attempts made to provide solutions.

RECENT PROGRESS

A final report on the legal and institutional study was completed. Because of the unsettled nature of geothermal legal and institutional problems, the report should be viewed as a status summary as of September 1977.

Legal support relative to the Navy's Coso, Lualualei, and Adak geothermal programs continued.

DOCUMENTATION

"Geothermal Legal/Institutional Study," TM 3165 (in process).

COSO GEOTHERMAL RESOURCE EVALUATION

Sponsor: NAVFAC
Performer: NWC
Contact: R. Fulmer and
C. Austin

Program Element 62765N

OBJECTIVE

The objective is to evaluate results of the ongoing USGS and DOE geological and geophysical studies being conducted at the Navy's Coso thermal area.

TECHNICAL APPROACH

The Coso thermal area at NWC is a very promising energy resource. Extensive geophysical/geological studies have been conducted by the Navy and USGS to evaluate the Coso resource. From these study results, DOE experts estimate the area to have an electrical power production potential of 4,000 MW—more than enough to operate all the DOD facilities in the Eleventh Naval District. DOE will drill exploratory wells at the site during FY 1977 to characterize the resource and determine the nature of the geothermal fluids involved. NWC will collect and evaluate results of the various study and drilling efforts to provide the Navy with a knowledge base for future decisions on the area.

SUMMARY OF PAST PROGRESS

The Navy's activities at the Coso thermal area date back to 1966 when a shallow (114 meter) well was drilled at the old Coso Hot Springs resort. Water at the bottom of the well

had a measured temperature of 142° C. Since then, numerous geological/geophysical studies have been run which have helped to locate the magma source and indicated the possible presence of a steam chamber and hot brine reservoir. Field measurements consisted of heat flow, geothermal ground noise, microearthquakes, gravity anomalies, magnetic anomalies, electrical resistivity, and aerial infrared studies. Also, USGS has conducted extensive geothermal studies of the structures involved using both aerial (satellite) and surface inspection techniques. Sixteen shallow (about 100 meters deep) heat flow holes followed by a deep slim hole were drilled by a DOE contractor (Battelle Northwest Laboratories). Drilling of the slim hole was terminated at 400 meters when technical difficulties prevented further drilling. DOE then decided to use its expertise to drill a production hole using a full-size contractor rig.

RECENT PROGRESS

Geological/geophysical studies by USGS and other agencies have continued. The DOE well contractor was chosen, the site prepared, and drilling initiated at a site close to the original slim-hole well. The new well is of production size rather than a slim hole. In November 1977, the well reached 1,478 meters deep and was cased to 1,067 meters. The drill rig was removed in early December and temperature logging was begun by DOE with Lawrence Berkeley Laboratory. The highest temperature recorded to date is 188° C. Plans for flow tests are being coordinated with DOE. NWC, under funding from DOE, is in charge of safety, security, and scheduling. For this task, NWC will continue to monitor activities in the area and assemble data needed for Navy evaluation of the area.

Following an expression of interest notice in the Commerce Business Daily issue of 14 October, a briefing was held for industry, public utilities and government personnel interested in development of 4 square miles of the Coso geothermal area.

A contract was awarded to remove the pump and pull the pump column to make Coso Well 1 suitable as an environmental control site. Coso Well 1 is about 275 feet deep and is located in the old Coso resort area.

Discussions were held at NWC to determine the Navy's environmental responsibility in developing fee-owned lands at the Coso site. The discussions resulted in the formulation of a preliminary outline for conducting an environmental review for development of Coso.

Estimated energy savings are 160,000 BOE per year.

ADAK ANALYSIS SUPPORT

Sponsor: NAVFAC
Performer: NWC
Contact: R. Fulmer

Program Element 62765N

OBJECTIVE

The objective is to provide analytical support to assess the technical and economic feasibility of using geothermal resources at Adak.

TECHNICAL APPROACH

Economic utilization analyses will be conducted to determine the merits of developing geothermal resources at Adak, Alaska, for providing heating and/or electrical power. An economic analysis study will be conducted first to compare the use of geothermal fluids (if they exist) as opposed to present fossil fuel systems, wind energy, tidal power, and nuclear power for supplying Navy facilities at Adak. Also, a piping study will be conducted to ascertain the technical and economic feasibility of piping geothermal fluids from potential resource sites to the principal Navy installations on the island.

SUMMARY OF PAST PROGRESS

The Adak economic utilization study was completed. The cost of using geothermal resources for heat and electricity was compared with that of the present system, which uses improved JP-5 aircraft fuel; a wind/hydrostorage system; nuclear power; and a tidal system. Results indicated that, if geothermal resources were found capable of producing heat in the temperature regime projected, the two geothermal approaches considered would definitely be attractive with a payback of less than 8 years.

A contract was awarded for a study to be conducted by Dr. Richard Ulrich of Brigham Young University on the engineering and economics of piping geothermal fluids at Adak.

RECENT PROGRESS

Comments were received on the Adak economic utilization study report draft. Appropriate corrections and additions were made, and the report distributed.

Contract studies at Brigham Young University on the engineering and economics of piping geothermal heating fluids in the Adak environment have proceeded. Preliminary results indicate that piping fluids is promising if the resource proves suitable. For instance, fluids from a geothermal power plant located in the area of Adak Well 1 or 2 could be piped to the main Navy facilities at a cost of around \$0.60 per million Btu for a 20-year period.

DOCUMENTATION

"A Technical/Economic Comparison of Alternate Energy Systems at Naval Station/Adak,"
TM 3243, August 1977.

GEOHERMAL UTILIZATION TECHNOLOGY FOR REMOTE NAVY SITES

Sponsor: NAVFAC
Performer: NWC
Contact: R. Fulmer

Program Element 62765N

OBJECTIVE

NWC is identifying ongoing Navy energy technology development programs having potential application to geothermal systems. Equipment being developed within the geothermal industry and suitable for use at remote Navy installations is being identified and tested at Navy locations.

TECHNICAL APPROACH

Navy energy programs will be surveyed to identify those devices under development that could be adapted easily for use with geothermal power sources. Also, programs under DOE and industry sponsorship will be reviewed to identify devices that would be particularly useful to the Navy.

SUMMARY OF PAST PROGRESS

Navy energy programs were examined to determine which devices being developed at CEL and elsewhere could be used with geothermal heat sources. Some potential was found to exist for the use of Rankine cycle power generators (under development for diesel bottoming cycles) and absorption air conditioning hardware (being considered for use with solar power). The helical screw expander, being developed by Hydrothermal Power Company for DOE, was also identified as a potentially important device for use at Navy geothermal locations. The helical screw expander can take in the entire geothermal flow of steam, water, chemicals, and fine dirt, and output shaft power required to drive a generator, pump, or other mechanical device. It can be pallet-mounted and would operate off the output of a single geothermal well, hence, eliminating extensive piping. The device can be configured from commercially available screw compressor parts in sizes up to 5 MW.

RECENT PROGRESS

Progress on the 1.2 MW helical screw expander under development by DOE was monitored; a short report describing the unit, which has been completed and is undergoing laboratory testing, was written and distributed. The expander was shipped to Roosevelt Spring, Utah, for testing (which should begin in February 1978). DOE was offered the future use of Coso for testing the device should the Coso well, under development by DOE, prove to be suitable.

Under contract with the Navy, Brigham Young University experts are studying geothermal fluid transport and utilization. A draft report on the technical feasibility of bringing

geothermal fluids from Coso to the main base activities was submitted for review. Various piping and insulating materials were examined for a pipeline over a typical route. Costing data were provided for the pipeline as a function of the activities at China Lake served by the line, the pipe size employed, the amount of auxiliary pumping used, pipe materials, and insulation thickness and type. Capital costs and breakeven periods are given for each option. Based on heating alone, energy costs of power delivered to China Lake would be about \$1.16 per million Btu. Use of absorption air conditioning for summer utilization of the fluids could reduce the cost to around \$0.70 per million Btu.

The Brigham Young University study on Adak piping is similar in nature to the one for Coso. Energy costs are somewhat lower because the distances are shorter and year-round heating is needed. The economics would be even more attractive if not for the high costs of installation and shipping to Adak.

Brigham Young University also conducted several smaller studies in support of geothermal utilization. One involved the use of absorption air conditioning in conjunction with geothermal hot waters. This approach appears technically feasible, but economic data were not developed. A second study involved use of a geothermal powered binary cycle with a modified reciprocating engine.

DOCUMENTATION

"Total-Flow Wellhead Concept—The Helical Screw Expander," TM 3242, September 1977.

GEOTHERMAL CORROSION STUDIES

Sponsor: NAVFAC
Performer: NWC
Contact: C. Austin

Program Element 62765N

OBJECTIVE

The objective is to investigate the corrosive action of Coso geothermal fluids on construction and military avionics/communication materials.

TECHNICAL APPROACH

Corrosion arrays will be installed on wells in the Coso thermal area, and the interaction between the site-specific fluids and selected construction materials required in geothermal power plants will be monitored. Selected communications and electronic components will be subjected to geothermal noncondensable gas environments, both actual and artificial, that may be encountered at the Navy's geothermal sites at Coso, Adak, and Lualualei.

SUMMARY OF PAST PROGRESS

Corrosion studies were conducted on three arrays at Coso, and the specimens were sectioned and analyzed for corrosion products. Types of corrosion identified included oxygen concentration cell corrosion, intergranular corrosion, pitting corrosion, and acid leaching of the cement from the transit pipe. The plastics outgassed and deformed because of heat stress.

RECENT PROGRESS

A report was written on last year's corrosion study and materials were ordered for this year's study effort.

DOCUMENTATION

"Coso Geothermal Corrosion Studies," TM 5974, October 1977.

ADVANCED AIR CONDITIONING SYSTEMS

Sponsor: NAVFAC
Performer: NWC
Contact: A. McClaine

Program Element 62765N

OBJECTIVE

The objective is to evaluate advanced air conditioning systems capable of utilizing local energy sources to identify the systems that can potentially provide the Navy with low-cost air conditioning as conventional fuels become scarce.

TECHNICAL APPROACH

Data will be collected from current research or demonstration programs throughout the United States, or will be generated as needed. The data will be used to perform life-cycle cost analyses for two cases: one assuming the system is installed in the current year, and one assuming the system is installed in 1985. Life-cycle cost analyses will also be performed for systems installed at various locations around the country. When completed, the costs will be compared to determine the most desirable locations and estimates of when the systems can be employed.

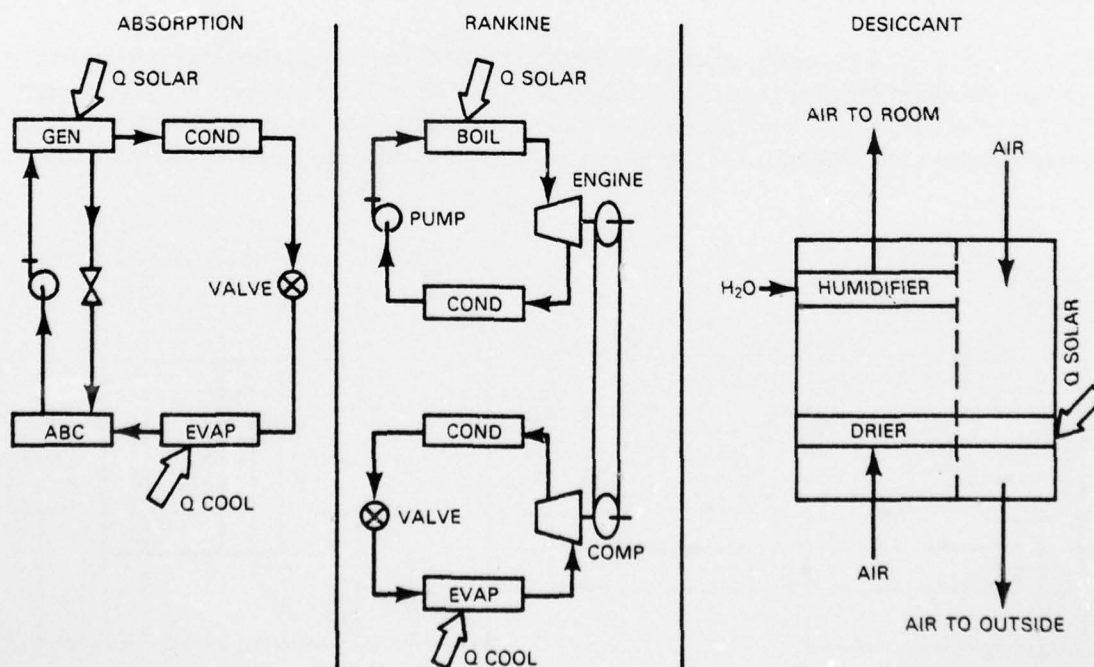
SUMMARY OF PAST PROGRESS

Arthur D. Little, Inc., was awarded a contract to study solar air conditioning. This effort was completed.

Planning began on analysis of two-stage ammonia-sodium thiocyanate absorption refrigeration systems for the purpose of generating data that can be used for life-cycle cost analyses.

The contract report from Arthur D. Little was published and disseminated. A contract was awarded to California State University, Northridge, for thermodynamic analyses of two-stage ammonia-sodium thiocyanate absorption refrigeration systems and a comparison of these with conventional systems.

"Solar Air Conditioning Study," CR 77.018, April 1977.



ADVANCED AIR CONDITIONING SYSTEMS

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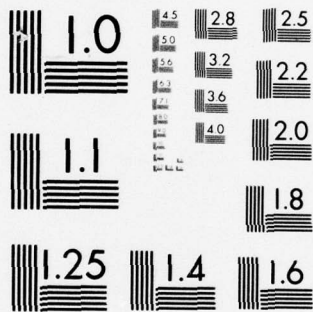
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SOLAR AUGMENTED HEAT PUMPS

Sponsor: NAVFAC
Performer: CEL
Contact: A. McClaine

Program Element 62765N

OBJECTIVE

The objective is to determine the feasibility and advantages of using solar augmented heat pumps (SAHPs) in Navy HVAC applications.

TECHNICAL APPROACH

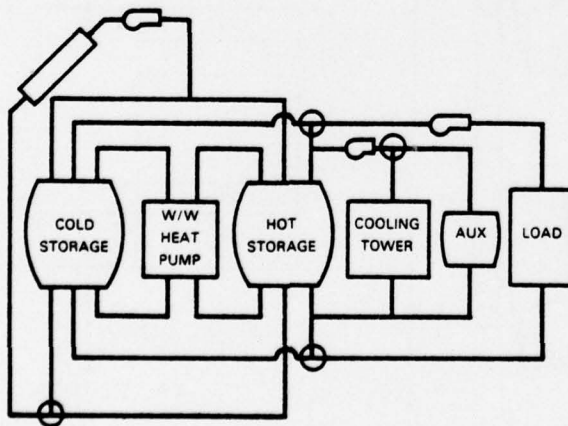
Selected SAHP systems will be analyzed by computer simulation to determine their energy use during a test year. Life-cycle cost analyses will then be conducted. Experimental data will be gathered to verify the results of the simulations and cost analyses. Costs and potential energy savings will be considered. If economical systems can be identified, a test unit will be designed and tested in the AEUTB.

SUMMARY OF PAST PROGRESS

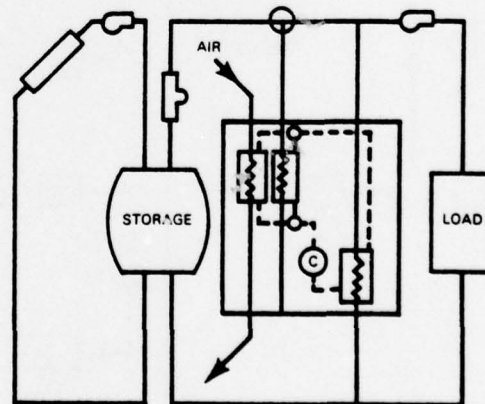
SAHP systems to be studied were identified, and an analysis procedure selected.

RECENT PROGRESS

The TRNSYS program, developed by the University of Wisconsin, was implemented on the Lawrence Berkeley laboratory computer system. Personnel involved with the project were trained in the use of the program. Simulation models were developed for three of the seven systems to be studied. Weather and insolation data were purchased and adapted to the



DUAL STORAGE SYSTEM



DUAL SOURCE HEAT PUMP SYSTEM

requirements of the TRNSYS program. The experimental systems to be used to verify the results of the simulation models were designed. Equipment was specified and ordered. A technical memorandum was written further detailing the plans and progress of this work unit.

Estimated energy savings are 1,600 BOE per year.

DOCUMENTATION

"Plans and Progress of the Investigation of Solar Augmented Heat Pumps at the Navy's Civil Engineering Laboratory," TM M-63-77-07, September 1977.

ENERGY STORAGE R&D

Sponsor: NAVFAC
Performer: CEL
Contact: B. Swaidan

Program Element 62765N

OBJECTIVE

The objective is to investigate and recommend energy storage systems for heating and cooling Navy buildings.

TECHNICAL APPROACH

Storage methods will be evaluated to identify, based on technical and economic feasibility, which systems could be integrated with solar and wind energy systems at remote bases. A contract to provide a comparative storage methods study will be awarded in FY 1978. Studies on specific methods will include thermal stratification, dissolved salts storage, and other chemical storage methods. Bench-scale experiments may be initiated for systems showing potential. Efforts will be coordinated with DOE storage R&D activities.

SUMMARY OF PAST PROGRESS

A contract was awarded to Colorado State University to improve the efficiency of thermal energy storage in water tanks by enhancing the thermal stratification. A literature search indicated very little had been published on thermal stratification enhancement. An inlet diffuser was designed to improve thermal stratification in hot water tanks; initial results from small-scale experiments are encouraging.

RECENT PROGRESS

The Colorado State University inlet diffuser was tested in a large-scale water tank; the results confirmed those obtained in small-scale tests. These results were documented.

A contract was awarded to University of Houston for thermal storage research using chemical reactions. Another contract was awarded to Thermal Instrument Company for thermal storage research using phase-change materials. Preparation was started on a work statement for a thermal stratification study. Preliminary contract reports were received on dissolved salt storage studies; a prototype is being built and tested.

Estimated energy savings are 120,000 BOE per year.

DOCUMENTATION

"Thermal Stratification Enhancement for Solar Energy Applications."

EVALUATION OF NEW COAL-UTILIZATION TECHNOLOGIES

Sponsor: NAVFAC
Performer: CEL
Contact: D. Williams

Program Element 62765N

OBJECTIVE

The objective is to monitor DOE and industry work on new coal systems to determine their applicability to Navy shore requirements.

TECHNICAL APPROACH

The economic and technical feasibility of different coal systems available to the Navy will be analyzed. Since coal is not clean burning, its use will often be at variance with environmental quality goals set forth by both EPA and NAVFAC. Also, handling fuel and ash requires additional equipment and manpower as well as increased equipment maintenance. Navy combustion hardware which is generally both small and diverse, has considerable potential for development. Techniques for reducing emissions of particulates, sulfur oxides, and nitrogen oxides will be investigated. Advances in fluidized-bed boiler technology will also be investigated along with stack-gas cleanup methods and coal beneficiation. In addition, transportation and coal conversion technologies will be evaluated.

SUMMARY OF PAST PROGRESS

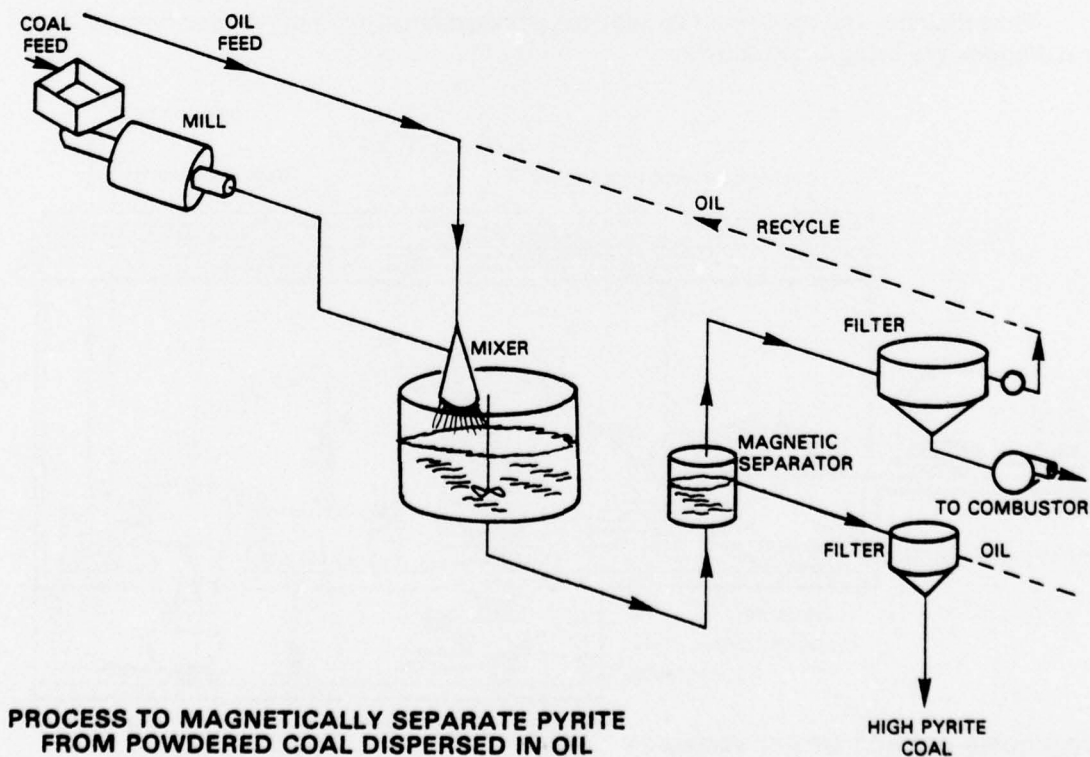
The fluidized-bed boiler is inherently small and less capital-intensive than conventional coal units and may present pollution control advantages. The contract for the DOE fluidized-bed boiler demonstration at the Great Lakes NTC was awarded to Combustion Engineering in July 1976. The state of Illinois and EPA are participating.

New developments in coal beneficiation technology, primarily the removal of pyritic sulfur, were investigated. Part of the magnetic separation of pyritic sulfur investigation at the Naval Ordnance Station, Indian Head, will be incorporated in the FY 1978 program.

General Motors was contacted about its double-alkali scrubber at Parma, Ohio. Although modifications have been required, the unit is operating. Capital and operating costs amount to \$13 per ton of coal burned.

The Woodall-Duckham Company modified a stoker-fed, coal-fired boiler in England to study fluidized-bed combustion. This type of modification is available for retrofit fluidized-bed combustion.

Research-Cottrell installed a Bahco sulfur dioxide and particulate removal system at Rickenbacker AFB, Columbus, Ohio. The system cleans 50,000 standard cubic feet of flue gas per minute from seven stoker-fired boilers burning 3.6 percent sulfur coal. The system was started in March 1976. Problems encountered have been primarily of a mechanical nature, often associated with startup. No process problems have been reported. Operating costs are \$6 to \$7 per ton of coal.



RECENT PROGRESS

A survey was made to compare the costs of rail transportation of coal and the pipeline transmission of coal-derived gases. Analysis of the results indicated that the cost of long-distance coal transport is independent of mode. In addition, the cost of large-scale synthetic natural gas manufacture is about the same as small-scale industrial fuel gas manufactured at its end-use point. Both will cost about \$4 per million Btu in 1977 dollars.

Estimated energy savings are 4,000,000 BOE per year (assuming several coal conversion options).

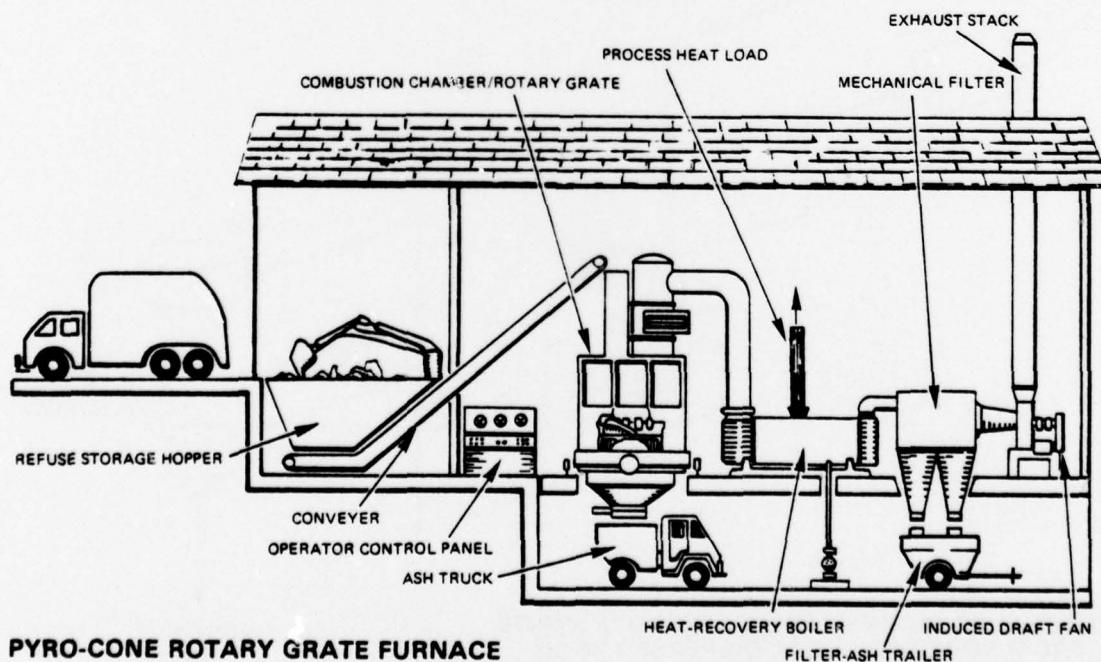
RECOMMENDATIONS FOR APPLICATION OF PACKAGED HEAT-RECOVERY INCINERATORS

Sponsor: NAVFAC
Performer: CEL
Contact: P. Stone

Program Element 62765N

OBJECTIVE

The reliability and economics of applying packaged heat-recovery incinerators at Navy installations are being determined.



TECHNICAL APPROACH

The burning capacity, overall efficiency, and other characteristics of controlled-air incinerators will be tested under contract. In addition, new installations will be visited. The best available packaged incinerator will be recommended for installation as a basic demonstration prototype. In addition, an incinerator at the Jacksonville, Florida, naval base will be modified to produce RDF for testing at various Navy boilers.

SUMMARY OF PAST PROGRESS

Preliminary economic and feasibility analyses, based on theoretical calculations, manufacturer's literature, and operating experience, were completed. Two operating tests were conducted, and results published.

RECENT PROGRESS

A contract was awarded for a 72-hour operating test. Six installations, either operating or being built, were visited and evaluated.

Estimated energy savings for 20 installations are 190,000 BOE per year.

SMALL-SCALE DENSIFIED REFUSE-DERIVED FUEL PROCESS EQUIPMENT

Sponsor: NAVFAC
Performer: CEL
Contact: D. Cross

Program Element 62765N

OBJECTIVE

The objective is to determine the effects of densified refuse-derived fuels (RDF) on combustion characteristics.

TECHNICAL APPROACH

Various densified RDFs, as well as other forms of processed and unprocessed RDF, will be evaluated in handling and comparative burning tests to determine the parameters desirable for packaged incinerators. (Past work in refuse densification at CEL has dealt primarily with feasibility and processing techniques for stability, transportability, and disposability, including the option of direct ocean disposal.) Reprocessing densified RDF for use in combined liquid and solid waste processes may be investigated, depending on which combined processes are determined most suitable for Navy use. Other sources of funding, such as DOE, will be sought to hasten completion of this project, or its transition to advanced and engineering development.

SUMMARY OF PAST PROGRESS

The U.S. Army Civil Engineering Resource Laboratory was given a work request to investigate sources of RDFs and problems associated with small-scale combustion of RDF for direct thermal conversion. Hardware requirements and possible sources of RDFs for small-scale combustion tests in a packaged incinerator were identified. Development of a test plan was started.

RECENT PROGRESS

Conceptual designs of small-scale solid waste transfer/resource recovery stations were developed and ranked according to life-cycle costs. Also, a computer program was developed for economic analysis of proposed changes in waste practices, such as implementation of source segregation, resource recovery, and transfer station operation. A final report was prepared.

Production of densified RDF for energy-recovery experiments was started. Development of a plan for instrumentation of an experimental test bed was also started.

DOCUMENTATION

"Project TRASH: Total Refuse Advanced Systems Handling."

CONVERSION OF SOLID WASTE TO GASOLINE

Sponsor: NAVFAC
Performer: NWC
Contact: C. Benham

Program Element 62765N

OBJECTIVE

The objective is to develop and demonstrate the technology needed to produce petroleum-like products (principally high-octane gasoline) from the organic fraction of trash, and to quantify the gasoline yield and energy efficiency.

TECHNICAL APPROACH

A three-step process will be demonstrated and quantified: (1) pyrolysis to produce olefins, (2) purification of pyrolysis gases to concentrate olefins, and (3) polymerization of olefins to gasoline. Raw municipal solid waste will be separated into organic and inorganic process streams using techniques now in full-scale development. The organic fraction will be pyrolyzed to form gaseous hydrocarbons suitable for purification and polymerization to high-octane gasoline. By-product gases and char will be used to supply the process energy.

SUMMARY OF PAST PROGRESS

Selective pyrolysis of organic waste to olefins was demonstrated successfully. This pyrolysis has yielded a 25 percent by weight conversion on a dry, ash-free basis (50 percent energy conversion). Pure ethylene (the predominant olefin) was reacted (polymerized) to form a synthetic crude oil containing 90 percent gasoline having a nonleaded motor octane of 90. Preliminary economic evaluations indicated that, using military economic rationale, a 100-ton-per-day plant would be economically attractive at gasoline prices above \$0.42 per gallon. Additional bench-scale process development work was started.

RECENT PROGRESS

Check-out of the solid waste-to-gasoline system continued. Problems were encountered with the lean oil pump, but it is now functioning. Further difficulties were encountered with the stripper component. The modified pyrolysis system was checked out and is working well. EPA contracted an expert from Dow Chemical to provide an independent third-party evaluation of the NWC trash-to-gasoline conversion system and of the potential for system scale-up and factors relative to siting a scaled-up system for use by the private sector.

SOLAR PROJECTS FOR THE ADVANCED ENERGY UTILIZATION TEST BED

Sponsor: NAVFAC
Performer: CEL
Contact: E. Durlak

Program Element 62765N

OBJECTIVE

The objective is to determine which solar collector, components, and systems are economically and technically feasible for use at Navy facilities.

TECHNICAL APPROACH

An AEUTB was built as part of the building design and energy analysis task. This will serve as a flexible test bed for full-scale solar collectors, storage techniques, solar stills, and solar dryers operating as a system integrated with advanced HVAC systems and building designs. Solar collectors will be analyzed and tested separately under contract particularly when test data are not available or when a concept's potential has been fully identified. Component tests may precede application on the AEUTB or a general recommendation for naval usage.

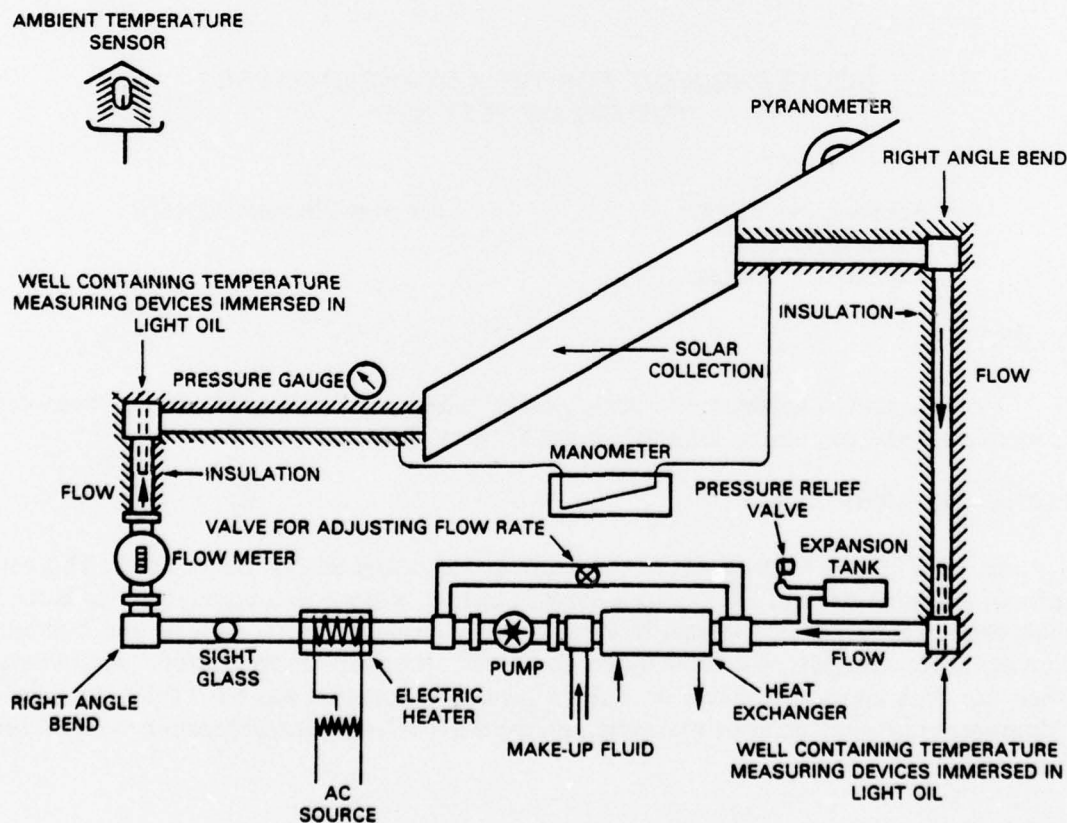
SUMMARY OF PAST PROGRESS

Computer programs were developed to reduce the digital data to engineering units and compute collector efficiency. The overall design of the solar collectors and storage system for the AEUTB was completed. Six solar collectors have been procured from Sunpower, AMSUN, PPG, Champerlin (NBS), Northrup, and Sunburst. Other collectors may be purchased in the future. Some collectors were evaluated on the AEUTB test stand. NBS tests of the PPG collector were completed.

RECENT PROGRESS

The design for the solar system to be installed on the AEUTB was completed. Subsequently, the solar system was installed on the AEUTB and initial pressure checks were completed. Operation of the system was analyzed using TR-835 and a computer simulation. CEL estimated that the system will provide an average of 50 percent of the thermal load of the AEUTB.

Three solar collectors were tested on the test stand consisting of two concentrating collectors and one flat-plate collector supplied by NBS. The concentrating collectors showed



SOLAR TEST CONFIGURATION OF AEUTB

poor performance because of problems involving the motor and tracking assemblies. The flat-plate collector, tested according to the NBS format, showed efficiencies of 40 to 75 percent.

Computer simulations were started showing the effect of using different types of solar collectors on the AEUTB. Estimates were made for total heat load, amount of energy collected, and overall system efficiency. These analyses will be used in subsequent computer simulations to predict the economic potential of selected solar systems.

Estimated energy savings are 1,154,000 BOE per year (assuming Navy-wide application of solar heating and cooling systems).

DOCUMENTATION

"Analysis of Solar Collectors Using National Bureau of Standards Test Criteria," TM M-63-77-3, May 1977.

SOLAR HEATING AND COOLING DESIGN GUIDE

Sponsor: NAVFAC
Performer: CEL
Contact: D. Pal

Program Element 62765N

OBJECTIVE

CEL is providing technical guidance to evaluate a given solar system at a selected site and to select or design system equipment.

TECHNICAL APPROACH

Technical guidance for evaluating a given solar system at a preselected site and for selecting or designing equipment for the systems will be presented in a solar design guide. This report is applicable to all types of Navy buildings and will be revised periodically and expanded to include cooling advancements, with emphasis on equipment and HVAC aspects of the total system.

SUMMARY OF PAST PROGRESS

A design guide was published on the "f chart" technique that enables a user to select a type of flat-plate collector system for heating a given structure. Data were collected on collector types and efficiencies, as well as on insolation levels at Navy CONUS sites.

RECENT PROGRESS

A systems analysis of the solar system at the AEUTB was completed using the computer program TRNSYS. Projected system performance was compared with system performance as predicted in "Solar Heating of Buildings and Domestic Hot Water," TR-835, April 1976. Good agreement was shown. Work to modify and improve CEL TR-835 was started, and includes improvements to the cost estimating technique, especially as related to component sizing; a review of the analytical techniques; a comparison with other similar manuals for content and ease of use; and development of a general scheme for estimating solar cooling applications.

RECOMMENDATIONS FOR CENTRAL SOLAR-ELECTRIC POWER GENERATION AT NAVY BASES

Sponsor: NAVFAC
Performer: CEL
Contact: J. Slaminski

Program Element 62765N

OBJECTIVE

Central solar-electric power plants are being monitored and evaluated to determine whether such plants can be used at Navy bases.

TECHNICAL APPROACH

A systems analysis study will be conducted to define optimum solar electric configurations to match specific Navy needs. Electric demand levels will be available from other studies. The national central solar-electric program will be monitored and evaluated for results applicable to the Navy.

SUMMARY OF PAST PROGRESS

It was concluded that emphasis should be on development of solar-electric turbine/generator modules that could be deployed in arrays.

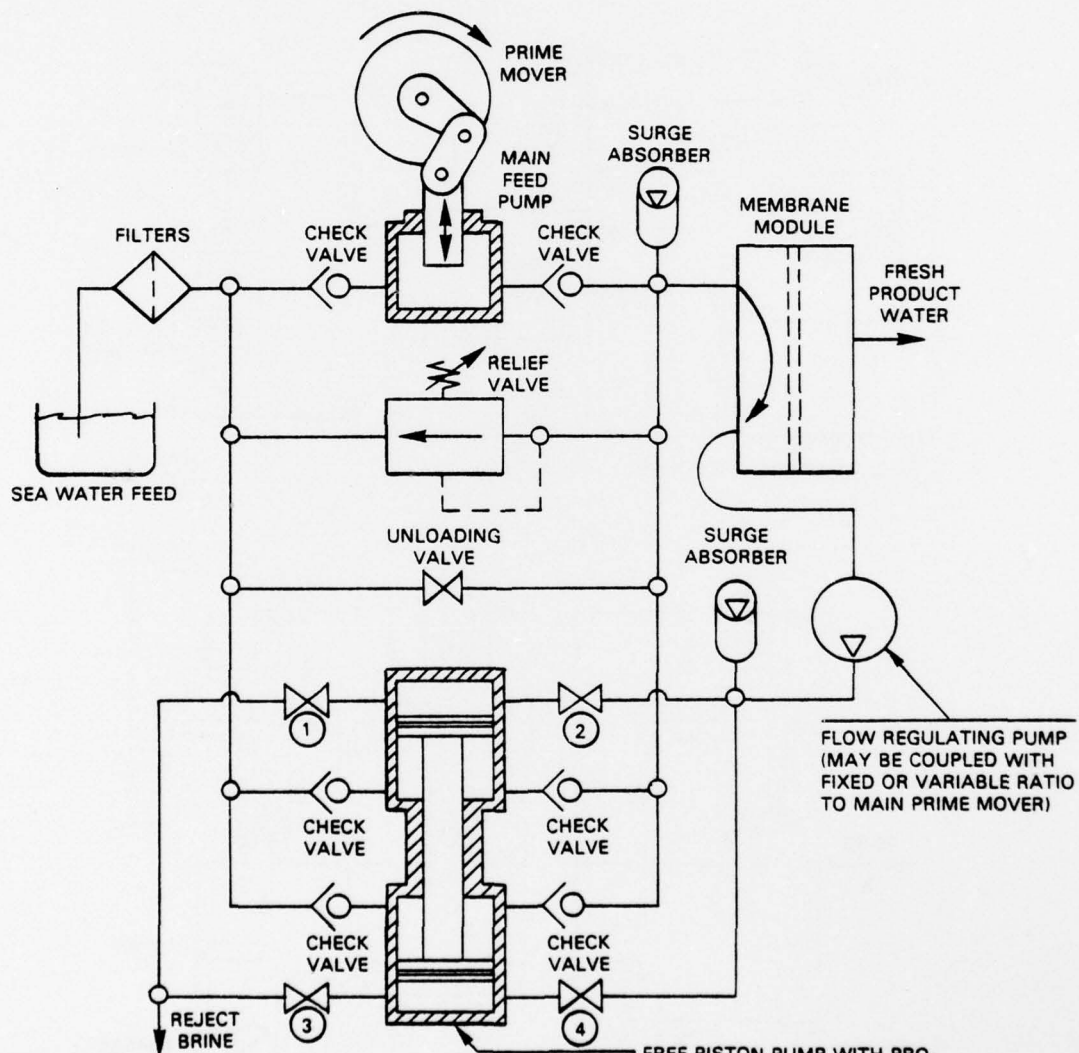
RECENT PROGRESS

CEL analyzed for use in 10 kW solar-electric turbine/generator units distributed arrays. This project was terminated at the end of FY 1977 to concentrate on other projects.

FEASIBILITY OF SOLAR DESALINATION APPLICATION AT NAVY SITES

Sponsor: NAVFAC
Performer: CEL
Contact: B. Swaidan

Program Element 62765N



N.B. Valves 1, 2, 3 and 4 are automatically controlled timing valves;
1 and 4 are open (closed) when 2 and 3 are closed (open).

FREE PISTON PUMP WITH PRO-
PRIETARY PILOT TIMING VALVES

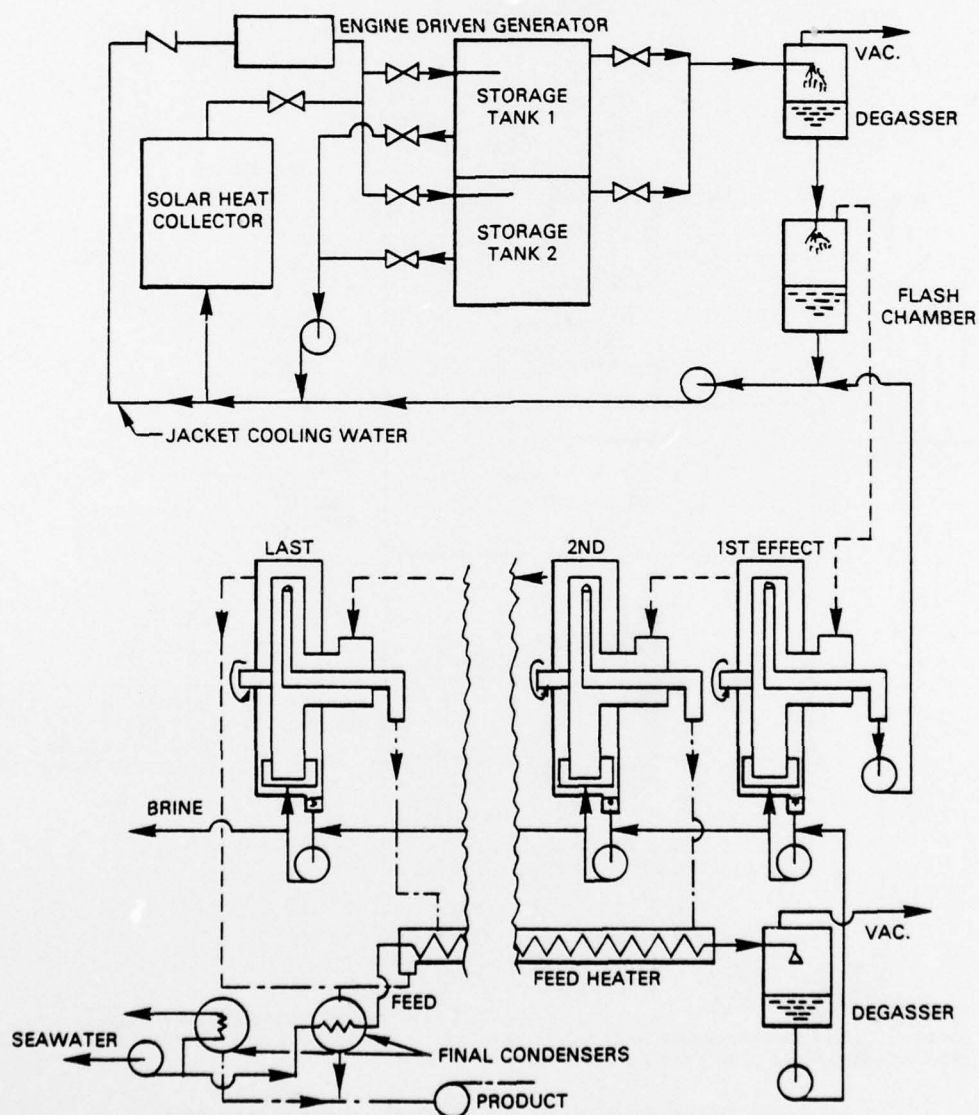
**SIMPLEX FREE PISTON ENERGY RECOVERY PUMP FOR
REVERSE OSMOSIS SYSTEM**

OBJECTIVE

The objective is to determine the feasibility, cost-effectiveness, and performance of solar desalination methods applied at Navy sites.

TECHNICAL APPROACH

A study will be conducted to determine which desalination methods can be economically powered with solar energy and which Navy base is most suitable for a solar desalination



ROTATING DISK WIPED-FILM EVAPORATOR MULTIEFFECT STILL

plant. A systems study will then be performed to determine the best method to be used at the selected Navy installations.

SUMMARY OF PAST PROGRESS

The literature and state-of-the-art review of solar desalination was completed, as was a survey of the Navy's freshwater needs. An economic study, computer optimization analysis, bench-scale experiments of several solar desalination concepts, analysis of single- and multiple-effects hemispherical solar still, and a computer optimization study on a high-performance solar still were also completed.

RECENT PROGRESS

The Navy's freshwater demand for FY 1976 was defined, and an economic analysis of solar desalination for water supply at advanced bases for various concepts was completed. A memorandum describing efforts on solar desalination for FY 1977 was drafted, and a paper on solar desalination for the Miami International Conference on alternative energy sources was issued. Evaluation of two solar still bench-scale models (a rotating disk wiped-film evaporator multi-effect still and a reverse osmosis system) in 500-hour tests was started. A material request to conduct a preliminary design, evaluation, and economic analysis of a solar-powered reverse osmosis seawater desalination system utilizing an energy recycling pump system was issued.

Estimated energy savings are to be determined case by case.

PRELIMINARY ASSESSMENT OF PHOTOVOLTAIC EQUIPMENT FOR NAVY BASES

Sponsor: NAVFAC
Performer: CEL
Contact: G. Beck

Program Element 62765N

OBJECTIVE

The objective is to collect data on photovoltaic systems to determine potential applications at Navy bases.

TECHNICAL APPROACH

A photovoltaic bibliography will be prepared and maintained.

SUMMARY OF PAST PROGRESS

Possible uses of photovoltaic energy for remote Navy facilities were investigated. The feasibility of using a large, collapsible, photovoltaic collector with containerized photovoltaic/battery power supply system was also investigated; a collapsible collector was judged inadequate because of the wind loads it would encounter. Preparation of a bibliography on photovoltaic equipment was started.

RECENT PROGRESS

Collection of bibliographic data continued. Feasibility studies for application of photovoltaics at specific Navy sites were conducted, and preliminary cost analyses of a photovoltaic system installed at Pinon Point near NWC, China Lake, were obtained.

PRELIMINARY DESIGN OF OPEN-CYCLE SOLAR-ELECTRIC TURBINE GENERATOR

Sponsor: NAVFAC
Performer: CEL
Contact: E. Cooper

Program Element 62765N

OBJECTIVE

The objective is to develop and test a tactical solar-to-electrical energy converter for advanced base operations to reduce the logistical burden associated with petroleum fuels.

TECHNICAL APPROACH

A design will be formulated for a 10 kW solar-to-electrical system utilizing a parabolic dish reflector, 700 to 870° C receiver, and an open-cycle air turbine. If competitive with other conversion approaches, a prototype will be fabricated and tested.

SUMMARY OF PAST PROGRESS

A prototype design of the solar air-turbine generator was completed. A statement of work was drafted and submitted for a contract to provide baseline design and marketing analysis for solar-electric turbine/generator modules.

RECENT PROGRESS

A complementary effort at Honeywell/Sandia/DOE and a potential preemptory effort at Jet Propulsion Laboratories/DOE were identified, resulting in decision not to award the contract mentioned above. Most of the funds were transferred to NWC, China Lake, for geothermal studies.

FLUID MECHANICAL SOLAR TRACKER

Sponsor: NAVFAC
Performer: CEL
Contact: C. Ward

Program Element 62765N

OBJECTIVE

The objective is to demonstrate the workability and accuracy of solar powered fluid mechanical drives for repositioning sun-tracking equipment, such as concentrating solar collectors.

TECHNICAL APPROACH

A small prototype tracker will be built and tested. The design will be submitted to DOE for further development.

RECENT PROGRESS

This project began in FY 1978. Construction of the prototype was started.

EVALUATION OF 5 TO 10 kW CAPACITY WIND GENERATORS TO SUPPLY POWER FOR BUILDINGS

Sponsor: NAVFAC
Performer: CEL
Contact: D. Pal

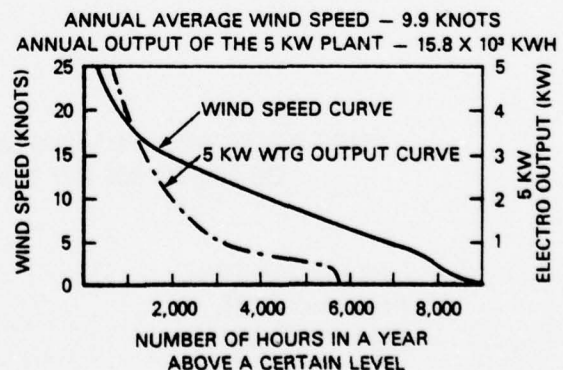
Program Element 62765N

OBJECTIVE

CEL is developing methods and power-conditioning hardware to convert the output of small-capacity wind machines to heat for environmental control of buildings or to 60 Hz constant-voltage electricity.

TECHNICAL APPROACH

A 5 kW capacity, horizontal-axis, three-bladed, propeller-driven, three-phase AC wind generator will be used to test synchronous inverters for grid in-



WIND SPEED AND POWER DURATION CURVES FOR SAN NICOLAS ISLAND (PMTIC)

tegration, solid-state inverters for stand-alone operation, and a CEL load-matching system for load sharing.

Operational data on the wind generator's performance for space heating will be collected in tests at Laguna Peak or San Nicolas Island. Automatic data recording equipment will be used to collect the field data for analysis on a digital computer. Methods and hardware developed during the wind power research at the AEUTB will be used to support a 4-year test program in the engineering development program.

SUMMARY OF PAST PROGRESS

The redesigned and rebuilt generator assembly performed well at the Laguna Peak site. A new power conditioning system using a CEL load matching device and a motor controlled autotransformer performed well on the 5 kW facility.

RECENT PROGRESS

The 5 kW generator test facility at Laguna Peak was disassembled and shipped to San Nicolas Island for further testing. Plans are under way to install the 5 kW system. Based on the data for San Nicolas Island, the 5 kW plant should generate about 11,500 kWh in a year. Also a $\frac{3}{4}$ kW commercial wind generator was installed at CEL to demonstrate application of wind power at the AEUTB. The plant has been operating well. CEL plans to develop hardware to integrate the wind generator with the AEUTB for controlled test.

Estimated energy savings are 300,000 BOE per year.

DOCUMENTATION

"Wind Generated Electric Power at Navy Sites," TN N-1485, June 1977.

"Field Testing of 5 kW Commercial Wind Generator with an Automatic Load-Matching Device for Utilizing Its Output," presented at International Solar Energy Congress, New Delhi, India, January 1978, Civil Engineering Laboratory, D. Pal.

SITE SELECTION FOR INSTALLATION AND TESTING OF 100 TO 200 kW WIND GENERATORS

Sponsor: NAVFAC
Performer: CEL
Contact: D. Pal

Program Element 62765N

OBJECTIVE

The objective is to select a feasible Navy site to install and test a DOE-developed large-scale generator.

TECHNICAL APPROACH

Candidate sites where the application of large-capacity (100 to 200 kW) wind generators may be cost-effective will be identified. Site wind characteristics will be determined for long-term field measurements, and will be analyzed for optimum siting of a 200 kW unit at one of the candidate sites. The 200 kW unit will be field tested for 3 years by integrating it with the base grid fed by a diesel generator.

SUMMARY OF PAST PROGRESS

Ten candidate sites for testing the 100 to 200 kW wind generator were identified, and a technique for longitudinal correlation of wind data with its applications to siting of wind power plants was developed. Further investigation showed that two sites, San Nicolas Island and Kaneohe Bay, appear to be the best for 100 to 200 kW wind generator tests based on economics and wind profiles.

RECENT PROGRESS

Monitoring of developments in large-scale wind turbine generator technology continued. Future efforts will be directed toward siting a 100 kW wind generator at San Nicolas Island and Kaneohe Bay.

Estimated energy savings are 400,000 BOE per year.

FEASIBILITY OF SMALL-SCALE VERTICAL- AXIS WIND MACHINES

Sponsor: NAVFAC
Performer: CEL
Contact: D. Pal

Program Element 62765N

OBJECTIVE

The objective is to investigate the feasibility and economics of converting wind energy directly into heat for space heating applications and electricity for use at Navy bases. The use of small-scale vertical-axis dispersed systems is being emphasized.

TECHNICAL APPROACH

The feasibility and economics of direct conversion of wind energy into heat for building environmental control will be established through field tests of three, 1 kW, vertical wind turbines at a Navy housing unit.

SUMMARY OF PAST PROGRESS

The three 1 kW machines were installed on the roof of a two-bedroom house at NWC, China Lake. Preliminary test results indicated some problems with the load matching, using the brake-drum arrangement. Also, the turbine rotor stalled severely at wind speeds above 16 mph. Consequently, data recording was discontinued, and the contractor was requested to make necessary adjustments to the brake drums and the turbine rotors.

RECENT PROGRESS

Following modifications to the 1 kW machines, additional tests conducted by the contractor showed no significant improvement in performance of the turbines. The problem stems from the stationary fins used to augment the speed. The fins perform adequately at very low speeds; at moderate to high winds, however, a severe stalling of the rotor destroys turbine performance. This conclusion was verified by field tests under semicontrolled conditions with the turbine running at nearly constant rotational speed. The results indicated a severe rotor stalling at speeds above 16 mph. The results of the test series are being included in a technical memorandum. This project was terminated and the machines removed.

WIND POWER SYSTEMS APPLICATIONS GUIDE

Sponsor: NAVFAC
Performer: CEL
Contact: D. Pal

Program Element 62765N

OBJECTIVE

The objective is to obtain performance parameters of wind generators and of the power conditioning equipment required for applying wind power at Navy bases.

TECHNICAL APPROACH

Design data, such as parametric curves and charts, will be presented in an application guide of wind power systems. The guide will be revised and updated periodically to include results from various field demonstrations as they become available. Also, promising wind power systems will be analyzed to determine life-cycle costs.

SUMMARY OF PAST PROGRESS

Software routines for analyzing the field data were developed. Because no significant data were available from the field tests, no extensive data analysis was done.

RECENT PROGRESS

Data from the 1 kW vertical-axis wind turbine demonstration at NWC, China Lake, were analyzed. The results indicate that the wind turbine setup needs major design modifications. The project was deferred until results of other field demonstrations are available.

ADVANCED POWER CYCLES FOR ADVANCED BASES

Sponsor: NAVFAC
Performer: CEL
Contact: E. Cooper

Program Element 62765N

OBJECTIVE

The objectives are to determine the technical and economic feasibility of using alternative fuels at remote Navy bases and to evaluate and recommend system changes that reduce the logistical problems of petroleum fuels.

TECHNICAL APPROACH

Systems will be developed for using solar energy for the production and use of synthetic fuels to generate electrical power at remote Navy and Marine bases. The choice of systems will be based on scenario assessments of the overall energy sequence (transport, storage, conversion, utilization) at remote or advanced bases. Hydrogen production through thermochemical and electrolytic processes will be investigated. The performance and relative advantages of engines and burners operating on synthesized fuels (hydrogen, ammonia, and methanol) will be selected for remote or advanced base applications.

SUMMARY OF PAST PROGRESS

A literature survey of hydrogen generation techniques was conducted.

RECENT PROGRESS

A report on the evaluation of a cascaded dielectric power convertor was issued. This project was not continued in FY 1978 because other projects were given higher priority.

DOCUMENTATION

"Evaluation of a Cascaded Dielectric Power Convertor for Use at Naval Bases."

ADAK GEOTHERMAL RESOURCE DEVELOPMENT

Sponsor: NAVFAC
Performer: NWC
Contact: C. Austin

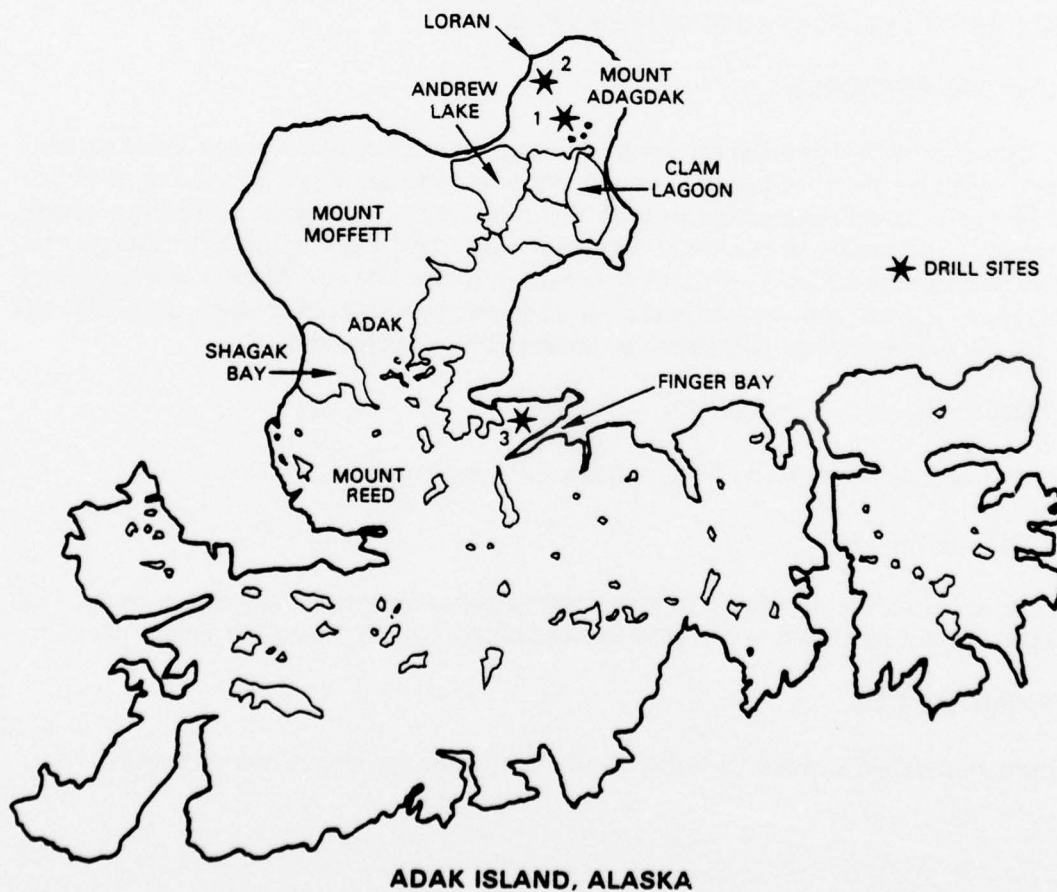
Program Element 63724N,
64710N, 65861N

OBJECTIVE

NWC is assessing the potential of Adak geothermal resources to provide electrical power and space heating for Navy facilities on that island.

TECHNICAL APPROACH

Geological studies will be conducted to determine the potential of the Adak geothermal resource for power and heating. Surface geological/geophysical studies will be conducted to evaluate the subsurface geothermal resource. Exploratory drilling will be done to verify the resource and to determine its characteristics and the nature of associated fluids.



SUMMARY OF PAST PROGRESS

Geophysical studies were conducted during FY 1976-1977 by USGS. Results indicated a promising resource; it was recommended that additional work be done to further pinpoint the resource. Arrangements were made for USGS to conduct geological studies at Adak during April and May 1977. Geochemical results indicated a resource with a minimum temperature of about 300° C at a depth of 600 meters.

RECENT PROGRESS

More extensive geophysical studies were conducted by USGS, and a drill site was chosen on the southeast slope of Mt. Adagdak. A contract was awarded to James A. Hamilton, Inc., of Anchorage, Alaska, to drill with a vehicle mounted Longyear rig. This equipment can drill cores to depths of about 2,000 feet (610 meters) in hard rock. Drilling at Adak started in August. The hole was drilled to 1,055 feet (322 meters) in clay and loose material. Drilling terminated because of hole squeeze, which required redrilling about 500 feet of material each time the bit was changed. The hole was completed with a steel liner to enable measurement of heat flow.

The rig was moved to a second site on the Loran Station road about 1.5 miles northwest of the first hole. The formation of the second site was also mixed clay and rocks, but hole squeeze was not encountered and the drill reached a depth of 628 meters. The bottom hole temperature was 66° C, which, although not sufficient for power production, could provide a source of heating water. This hole was also completed with a steel liner to enable continued temperature monitoring and swabbing tests for fluid at a later date.

The third hole at Adak, in the Finger Bay area, was abandoned at a depth of 120 feet (37 meters) because of extensive wash-in problems from an underground watercourse, bad weather, and contract limitations. Heat flow measurements will be taken at the first two holes next spring.

Estimated energy savings are 171,400 BOE per year.

DOCUMENTATION

"Preliminary Report on Geophysical Techniques Applied to the Evaluation of the Geothermal Potential of Adak Island, Alaska," November 1976.

FIELD TESTING OF 5 TO 20 kW CAPACITY WIND GENERATORS FOR BUILDING POWER SUPPLY

Sponsor: NAVFAC
Performer: CEL
Contact: D. Pal

Program Element 63N24N

OBJECTIVE

Data on wind turbine performance at selected Navy bases are being obtained.

TECHNICAL APPROACH

Wind turbines with a generating capacity of 6 kW or more will be tested with power-conditioning systems at four Navy bases to collect performance and O&M data.

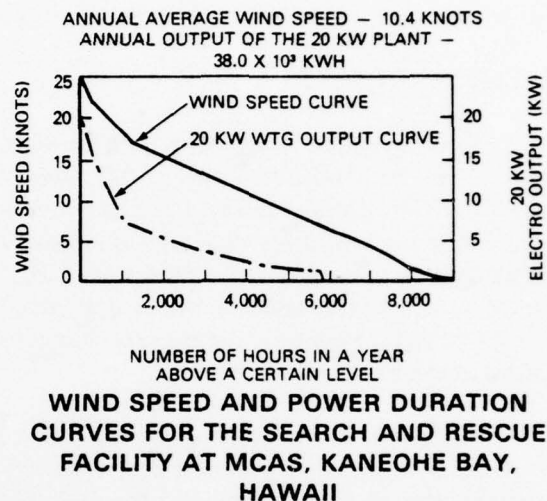
SUMMARY OF PAST PROGRESS

Four Navy facilities—Kaneohe Bay, Hawaii; Adak, Alaska; Fishers Island; and Pinon Peak, NWC, China Lake—were selected for field demonstrations in FY 1978 and FY 1979. The demonstrations at the four sites will involve:

- Kaneohe Bay—15 kW wind plant with a synchronous inverter to supplement demand of waterfront search and rescue facility.
- Fishers Island—10 kW wind plant with a synchronous inverter to a grid as a supplemental power source.
- Adak—10 to 20 kW wind plant with the CEL load matching system as a fuel saver for space heating.
- Pinon Peak—6 kW wind plant with battery storage as a stand-alone unit for a remote radar facility.

RECENT PROGRESS

Data for the Kaneohe Bay site were analyzed to develop the wind velocity and power duration curves. The electrical demand characteristics of the demonstration load revealed an excellent correlation with the diurnal wind cycle. A 15 kW commercial plant with a synchronous inverter will be installed in February 1978 and evaluated for 3 years to demonstrate use of wind generators as supplemental power sources. Concurrently, a 6 kW wind plant is under procurement for preliminary testing at CEL.



DEVELOPMENT OF A NAVY ENERGY SELF-SUFFICIENCY PLAN/DEMONSTRATION

Sponsor: NAVFAC
Performer: NFAC-032
Contact: R. Fulmer

Program Element 63N24N

OBJECTIVE

The objective is to provide guidelines to Navy installations for selection, identification, and integration of alternative energy sources that would provide a maximum level of self-sufficiency.

TECHNICAL APPROACH

An exemplary plan and demonstration at NWC, China Lake, will be accomplished in three phases. In Phase I, NWC's energy needs will be analyzed, and available alternative energy resources, viable energy storage systems, and any environmental, legal, or mission impacts that might result from the proposed program will be identified. Considering the possible effects, energy requirements identified will be matched to the available alternative energy resources. Preliminary designs will be developed for the more promising options, and a data base established for costs, risks, technical difficulties, and systems impacts. Phase I will conclude with the preparation of a data package, including a proposed plan for development, which will serve as the basis for a decision on the Phase II effort.

During Phase II, a contract will be awarded to an architect-engineering organization for conducting a systems design of the NWC self-sufficiency system. Detailed cost data will be obtained, and a better evaluation made of the potential risks and impacts. Research and development will continue in those areas needed for NWC self-sufficiency where technical deficiencies exist.

Following a review at the end of Phase II, there will be a two-part Phase III effort: Phase IIIA will include a detailed design of the system and the initiation of procurement of long-lead-time items; Phase IIIB involves construction of the required systems.

SUMMARY OF PAST PROGRESS

Work on the basic program plan continued through March 1977 and was nearly completed. Analyses of NWC energy needs and identification of energy resources were started. Collection of data on solar, wind, and geothermal resources was also started.

RECENT PROGRESS

The basic program plan was completed.

SOLAR DESALINATION DESIGN AND TESTING

Sponsor: NAVFAC
Performer: CEL
Contact: B. Swaiden

OBJECTIVE

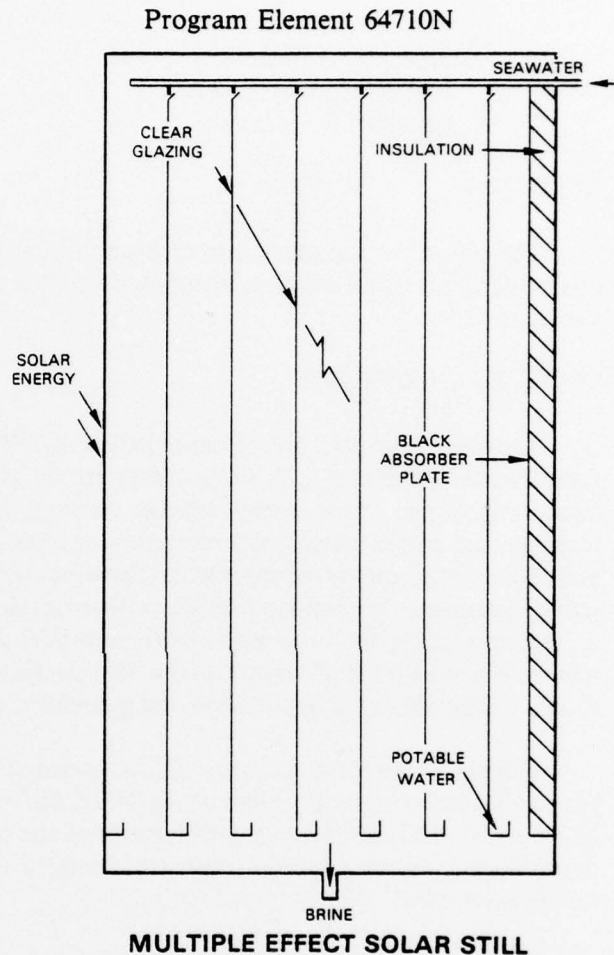
The objective is to design a multiple effect solar still that can be used at remote Naval facilities.

TECHNICAL APPROACH

An analytical investigation will be done to obtain design parameters for working engineering models. Bench models will be built, and laboratory experiments conducted.

RECENT PROGRESS

This project began in FY 1977. Conceptual models for solar desalination were designed on contract and delivered to CEL.



HEAT OF SOLUTION AIR CONDITIONING

Sponsor: NAVFAC
Performer: CEL
Contact: E. Swaidan

Program Element 64710N

OBJECTIVE

CEL is providing an engineering study and a working model of a solar-powered endothermic refrigeration system for Navy use.

TECHNICAL APPROACH

A complete thermodynamic analysis of the system will be performed followed by design development of a bench model for laboratory experiments.

RECENT PROGRESS

This project began in FY 1978. Material requests were issued for the preliminary design and bench experiment of a solar-powered endothermic refrigeration system.

HANDBOOK OF ALTERNATIVE ENERGY SYSTEMS

Sponsor: NAVFAC
Performer: CEL
Contact: W. Lorman

Program Element 64710N

OBJECTIVE

The objective is to compile a digest of operational requirements, physical characteristics, and potential outputs of solar, wind, and geothermal energy systems being developed by the Navy.

TECHNICAL APPROACH

Existing information will be collected to ascertain requirements, characteristics, and outputs of each of the three systems. Factors that affect output and cost of energy producible with each system will be identified.

RECENT PROGRESS

This project began in FY 1977. Data on wind turbine generators were compiled, and the corresponding section of the technical memorandum completed.

NEW GEOTHERMAL SITE EVALUATION

Sponsor: NAVFAC
Performer: NWC
Contact: F. Austin

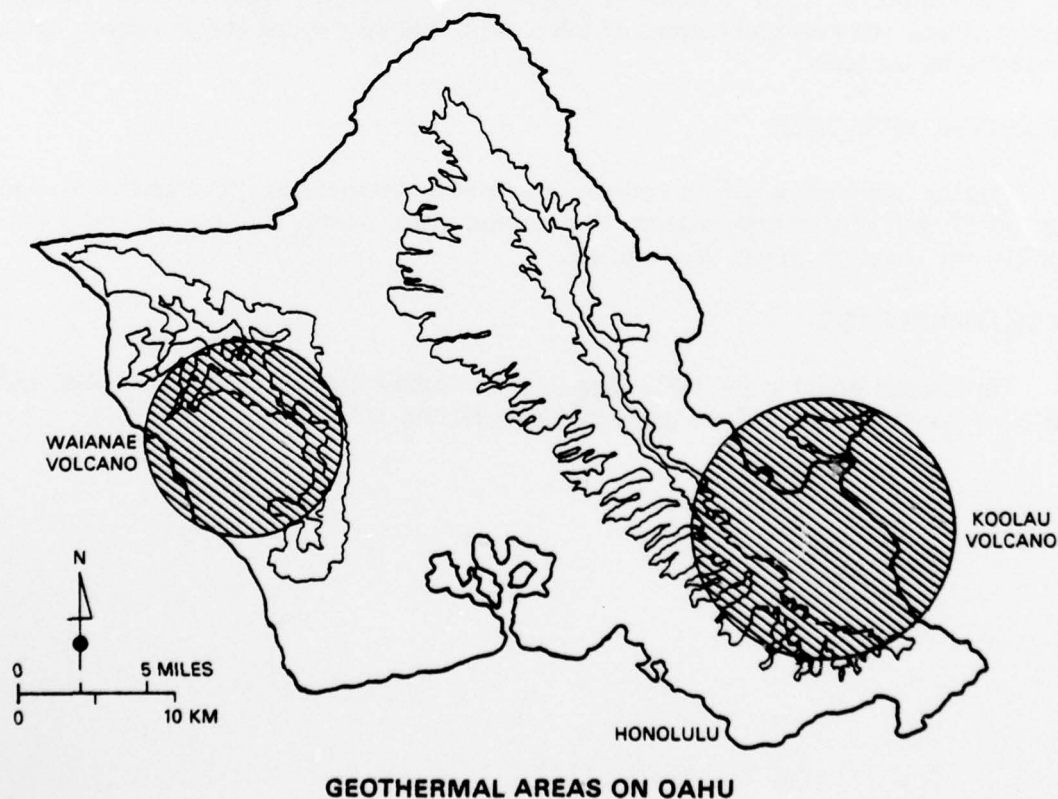
Program Element 65861N

OBJECTIVE

The objective is to evaluate the geothermal potential of promising Navy sites through detailed geological, geophysical, and geochemical analyses and economic utilization studies.

TECHNICAL APPROACH

Based on results of the Navy geothermal site assessment study, Navy sites with geothermal potential will be chosen for detailed field exploration. Exploration will include surface studies using geological, geophysical, and geochemical techniques to obtain knowledge on the location and size of the geothermal resource, its characteristics, and possible utility for Navy purposes. The economic feasibility of developing the geothermal energy for a site should a good resource be found will be determined. Based on the surface studies and economic analysis, a decision will be made as to whether exploratory drilling is advisable. Environmental studies will be pursued as necessary.



SUMMARY OF PAST PROGRESS

NWC participated in partial evaluation of one new site—NAD, Lualualei, Oahu Island, Hawaii. Based on a proposal by a commercial organization to drill an exploratory geothermal well on the Navy property at Lualualei, a surface examination was made, and a literature search and preliminary environmental studies were conducted.

RECENT PROGRESS

NWC advised and supported NAVFAC in its investigation of possible geothermal development at Lualualei. An architect and engineering firm was awarded a contract to investigate and make recommendations on the operational constraints at the Naval Magazine required of a contractor, data provisions, escape clauses to any contracts, environmental provisions, and fiscal arrangements. NWC will assist in the evaluation of the study results. In addition, NWC has completed preliminary environmental assessments for the proposed drill sites at NAD, Lualualei. State and county environmental groups were contacted, a literature search made, and field work conducted. The proposed drill sites at Lualualei have no prehistoric or historic sensitivities; however, any alternative locations will have to be examined because of archeological resources in the area. A number of Navy sites are under consideration for follow-on geothermal exploration. High on the list is NAS, Fallon, Nevada. It is close to the known geothermal resource areas of Stillwater-Soda Lake, Salt Wells Basin, and Brady Hazen.

Estimated energy savings at Oahu are 494,500 BOE per year.

APPENDIX A

NAVY ENERGY R&D PROJECTS

APPENDIX A

NAVY ENERGY R&D PROJECTS

ENERGY CONSERVATION

<u>Program Element Number</u>	<u>Title and Description</u>	<u>Performer</u>	<u>Contact</u>	<u>Telephone Number</u>
62765N	Energy Optimization Handbook for Navy Base Planning Provide a handbook of predetermined optimum mixtures of environmentally driven power systems and energy conservation systems for naval applications.	CEL	C. Parker	(805) 982-4326
62765N	Existing Energy Monitoring and Control Systems Determine additional costs and problems that arise from expansion of existing EMCS.	CEL	D. Johnson	(805) 982-5795
62765N	Advanced Energy Monitoring and Control Systems Concepts Investigate and evaluate advanced EMCS, emphasizing high-technology computer systems and their impact on energy monitoring and control.	CEL	D. Johnson	(805) 982-5795
62765N	Alternate HVAC Systems Study Provide Navy designers and planners with tools to aid in the design and choice of alternative HVAC systems capable of reducing energy consumption and system cost.	CEL	A. McClaine	(805) 982-4207
62765N	Construction Methods and Materials Conduct investigation to determine what information about energy conservation of construction materials and methods is lacking and recommend steps necessary to obtain the required data.	CEL	E. Vinieratos	(805) 982-5973
62765N	Heating and Cooling Loads Computer Simulation Assist in joint federal effort in the further development of the Loads and System Simulation (LASS) computer model.	CEL	E. Vinieratos	(805) 982-5973
62765N	Lighting Design Criteria for Navy Applications Perform laboratory and functional experiments to examine the effects of lighting quality and energy consumption.	CEL	W. Pierpoint	(805) 982-5778
62765N	Measurement of Energy Losses in Pipelines Evaluate through use of instrumentation the location and quantification of energy losses from steam, air, water, and gas pipelines, both exposed and buried.	CEL	J. King	(805) 982-5973
62765N	Measurement of Building Energy Losses Develop and standardize techniques for measuring air leakage rates of Navy buildings.	CEL	J. King	(805) 982-5973
62765N	Energy Systems Planning and Optimization Survey Navy shore establishment for the economic feasibility of alternative energy systems and provide economic data for planning the development of alternative energy systems.	CEL	T. Shugar	(805) 982-4653
62765N	Low Energy Structures Test and evaluate low-energy structures concepts for new construction and retrofit applications that will satisfy the need for reduced energy consumption.	NWC	D. Wirtz	(714) 939-7273

ENERGY CONSERVATION (Cont'd)

Program Element Number	Title and Description	Performer	Contact	Telephone Number
62765N	Data Compilation for Energy Consumption Compile on-site data and statistics related to energy demand and consumption at naval installations.	CEL	R. Bergman	(805) 982-5377
62765N	Electrical Equipment Conservation Evaluate equipment and distribution systems technology for electrical equipment conservation and for use in conjunction with alternative energy sources.	CEL	B. Milner	(805) 982-5468
62765N	Cogeneration Studies Investigate the potential of converting selected Navy bases to cogeneration, and provide background guidance for conversion.	CEL	E. Cooper	(805) 982-5975
62765N	Application Engineering Studies Provide RDT&E assistance to coordinate a continuous flow of technology from national energy programs to Navy field activities.	CEL	F. Herrmann	(805) 982-5562
63724N	Instrumentation Packages for Field Surveys Survey and select suitable instrumentation and formulate a user's guide for conducting field surveys of energy losses for all EFDs.	CEL	J. King	(805) 982-5973
63724N	Polyurethane Foam Roofing Systems Determine the fire safety and thermal efficiency of polyurethane foam roofing systems applied directly to a metal roof.	CEL	R. Alumbaugh	(805) 982-4679
63724N	Lighting Systems Experiments Develop methods to conserve electricity in lighting while maintaining and improving high-quality illumination.	CEL	W. Pierpoint	(805) 982-5778
63724N	Seawater Cooling Survey Determine the Navy-wide potential of sea/lake water air conditioning.	CEL	J. Ciani	(805) 982-4642
64710N	Organic Rankine Bottoming Cycle for Diesels Demonstrate an improvement in central power plant efficiency through the use of low-temperature heat-recovery systems.	CEL	H. Gaberson	(805) 982-5975
64710N	Seawater Cooling for Buildings Design, fabricate, install, and test a prototype sea/lake water cooling system at a Navy facility.	CEL	J. Ciani	(805) 982-4642
64710N	Application Potential of Energy Conversion Systems Assess the potential application of and conduct market surveys for alternative energy systems throughout the Navy shore establishment.	CEL	C. Parker	(805) 982-4326
62765N	Energy Conservation Aboard Ship Identify the potential for reduced fuel consumption in future ships through alternative propulsion and auxiliary options.	DTNSRDC	C. Krolick	(301) 267-2674
63724N	Advanced Ship Components Provide model tests and hardware demonstrations of machinery systems and components for the present and future fleets.	DTNSRDC	C. Krolick	(301) 267-2674

ENERGY CONSERVATION (Cont'd)

<u>Program Element Number</u>	<u>Title and Description</u>	<u>Performer</u>	<u>Contact</u>	<u>Telephone Number</u>
63724N	Biofouling Prevention and Removal Develop advanced techniques for waterborne removal of hull fouling and develop advanced antifouling and drag reducing hull coatings.	DTNSRDC	C. Krolick	(301) 267-2674
63724N	Improved Hull and Appendage Design Identify candidate designs for ship hulls, appendages, and propulsors that will reduce power loss and increase efficiency.	DTNSRDC	C. Krolick	(301) 267-2674
64710N	Fuel Oil Stripping Determine the extent of usable fuel lost due to shipboard fuel tank stripping and recommend solution.	DTNSRDC	C. Krolick	(301) 267-2674
64710N	Stack Gas Analyzer Develop an automated combustion control system that maintains combustion air at peak efficiency.	DTNSRDC	C. Krolick	(301) 267-2674
64710N	Machinery Optimization Identify energy intensive machinery systems aboard ship and optimize through equipment and operational modifications.	DTNSRDC	C. Krolick	(301) 267-2674
64710N	Performance Monitoring Continually monitor variables in ship operations and notify operators of inefficiency for rectification.	DTNSRDC	C. Krolick	(301) 267-2674
64710N	Water Resources Management Formulate water resource management techniques to improve the efficiency of freshwater production and use aboard ship.	DTNSRDC	C. Krolick	(301) 267-2674
64710N	Hull Coatings Test organometallic polymers at sea for prevention of marine fouling.	DTNSRDC	C. Krolick	(301) 267-2674
64710N	Hull Cleaning Conduct sea trials to determine acceptable hull cleaning techniques and cost effectiveness.	DTNSRDC	C. Krolick	(301) 267-2674
64710N	2,000 kW Quiet Diesel Generator Procure, test, and evaluate a quiet diesel generator set suitable for installation on ASW combatants.	DTNSRDC	C. Krolick	(301) 267-2674
64710N	Shipboard Combustion System Improvements Improve the efficiency of shipboard propulsion systems by reducing the excess boiler air requirements.	DTNSRDC	C. Krolick	(301) 267-2674
62765N	Aircraft Fuel Conservation Investigate and identify ways to conserve energy during operation of current inventory Navy aircraft.	NADC	C. Lampart	(213) 441-2575

SYNTHETIC FUELS

<u>Program Element Number</u>	<u>Title and Description</u>	<u>Performer</u>	<u>Contact</u>	<u>Telephone Number</u>
62765N	Aircraft Fuel Characterization Analyses Evaluate the chemical and physical suitability of synthetic and broadened specification conventional fuels for use in aircraft.	NAPC/NRL	C. Nowack	(609) 822-1414
62765N	Synthetic Fuels Laboratory Test Program Evaluate the physical and chemical characteristics of synthetic residuals and fuel oils for comparison with conventional fuels.	CEL	T. Fu	(805) 982-5975
62765N	New Energy Sources/New Fuel Sources Determine the basic properties of syncrudes and synthetic fuels and determine the suitability of using these fuels in Navy ships.	DTNSRDC	C. Krolick	(301) 267-2674
63724N	Small-Scale Aircraft Engine Testing with Synthetic Fuels Determine the effect of using synthetic JP-5 derived from coal, oil shale, and tar sands.	NAPC	L. Maggetti	(609) 882-1414
63724N	Coal Utilization Systems—Central Coal-Gasification Plant Determine if a central coal-gasification plant that would remove sulfur and particulates from fuel gas is feasible and economical.	CEL	D. Williams	(805) 982-4207
63724N	Small-Scale Tests with Synthetic Fuels for Facilities Test synthetic fuels in small-scale components to determine their acceptability for use in Navy shore facilities.	CEL	T. Fu	(805) 982-5975
64724N	Light Refined Liquid Fuels for Ships Perform studies on synthetic fuel impact in terms of system compatibility, logistics and handling problems, fire and safety hazards, and toxicological effects. Consider broader synthetic fuel specifications to allow greater fuel flexibility.	DTNSRDC	C. Krolick	(301) 267-2674

SELF-SUFFICIENCY

<u>Program Element Number</u>	<u>Title and Description</u>	<u>Performer</u>	<u>Contact</u>	<u>Telephone Number</u>
62765N	Navy Geothermal Site Assessment Identify and rank geothermal potential at Navy sites and recommend geological and geophysical studies required to assess its potential.	NWC	R. Fulmer C. Austin	(714) 939-7350
62765N	Geothermal Impact on Navy Missions Identify and document the impact of geothermal exploration, development, and utilization on the basic missions of Navy shore facilities.	NWC	C. Austin	(714) 939-2700
62765N	Geothermal Legal and Institutional Studies Identify and explore the legal, institutional, and operational interface considerations that exist in the exploration and development of geothermal resources on Navy property. Provide guidelines to the Navy in the use and management of such resources.	NWC	R. Fulmer	(714) 939-7350
62765N	Coso Geothermal Resource Evaluation Evaluate results of USGS and DOE geological and geophysical studies at the Navy's Coso thermal area.	NWC	R. Fulmer C. Austin	(714) 939-7350
62765N	Adak Analysis Support Assess the potential of Adak geothermal resources to provide thermal and electrical power for Navy facilities on Adak Island.	NWC	R. Fulmer	(714) 939-7350
62765N	Geothermal Utilization Technology for Remote Navy Sites Identify ongoing Navy energy technology efforts applicable for use in geothermal systems and conduct experiments using this technology.	NWC	R. Fulmer	(714) 939-7350
62765N	Geothermal Corrosion Studies Explore the causes and nature of corrosion of construction materials resulting from contact with various geothermal fluids.	NWC	C. Austin	(714) 939-2700
62765N	Advanced Air Conditioning Systems Perform economic evaluation and comparison of solar-driven absorption air conditioning systems.	CEL	A. McClaine	(805) 982-4207
62765N	Solar Augmented Heat Pumps Investigate and recommend energy storage systems for heating and cooling Navy buildings.	CEL	A. McClaine	(805) 982-4207
62765N	Energy Storage R&D Evaluate current systems for applicability to Navy use.	CEL	D. Pal	(805) 982-5119
62765N	Evaluation of New Coal-Utilization Technologies Monitor DOE fluidized-bed boiler demonstration and other developments in new coal systems technology.	CEL	D. Williams	(805) 982-5974
62765N	Recommendations for Application of Packaged Heat-Recovery Incinerators Assess economic and technical feasibility.	CEL	P. Stone	(805) 982-4207
62765N	Small-Scale Densified Refuse-Derived Fuel Process Equipment Determine parameters desirable in densified RDF for direct thermal conversion to energy in small, packaged units.	CEL	P. Stone	(805) 982-4207
62765N	Conversion of Solid Waste to Gasoline Develop and demonstrate the capability to economically generate gasoline from organic municipal and agricultural waste.	NWC	C. Benham	(714) 939-7263

SELF-SUFFICIENCY (Cont'd)

Program Element Number	Title and Description	Performer	Contact	Telephone Number
62765N	Solar Projects for the Advanced Energy Utilization Test Bed Test solar collector and storage methods integrated with HVAC systems.	CEL	E. Durlak	(805) 982-4207
62765N	Solar Heating and Cooling Design Guide Provide technical guidance for site selection and evaluation of solar systems.	CEL	D. Pal	(805) 982-5119
62765N	Recommendations for Central Solar-Electric Power Generation at Navy Bases Evaluate possible applications for solar-electric power generation at Navy bases.	CEL	J. Slaminski	
62765N	Feasibility of Solar Desalination Application at Navy Sites Determine the most suitable method of desalination for Navy needs and the most applicable Navy site for demonstration.	CEL	B. Swaiden	(805) 982-5978
62765N	Preliminary Assessment of Photovoltaic Equipment for Navy Bases	CEL	G. Beck	
62765N	Preliminary Design of Open-Cycle Solar-Electric Turbine Generator Develop preliminary design of a tactical solar-to-electric energy converter for advanced base operations.	CEL	E. Cooper	(805) 982-4207
62765N	Fluid Mechanical Solar Tracker Demonstrate the workability and accuracy of solar powered fluid mechanical drives for repositioning sun-tracking equipment.	CEL	C. Ward	
62765N	Evaluation of 5 to 10 kW Capacity Wind Generators to Supply Power for Buildings Establish applicability of wind generators in this power range to supply thermal or electrical energy to Navy buildings.	CEL	D. Pal	(805) 982-4207
62765N	Site Selection for Installation and Testing of 100 to 200 kW Wind Generators Determine candidate sites where DOE developed large wind machines are cost-effective. Collect and analyze field data to establish site characteristics for installation of candidate systems.	CEL	D. Pal	(805) 982-4207
62765N	Feasibility of Small-Scale Vertical-Axis Wind Machines Determine feasibility of small-scale vertical-axis wind machines for conversion of wind energy for space heating.	CEL	D. Pal	(805) 982-4207
62765N	Wind Power Systems Applications Guide Obtain performance parameters of wind generators.	CEL	D. Pal	(805) 982-4207
62765N	Advanced Power Cycles for Advanced Bases Determine technical and economic feasibility of using alternative fuels at remote Navy bases.	NWC	E. Cooper	(805) 982-5975
63724N 64710N 65861N	Adak Geothermal Resource Development Drill exploratory well to verify and characterize resource. Assess potential of Adak site for geothermal development.	NWC	C. Austin	(805) 939-2700

SELF-SUFFICIENCY (Cont'd)

<u>Program Element Number</u>	<u>Title and Description</u>	<u>Performer</u>	<u>Contact</u>	<u>Telephone Number</u>
63N24N	Field Testing of 5 to 20 kW Capacity Wind Generators for Building Power Supply Obtain performance data on wind turbines at selected Navy bases.	CEL	D. Pal	(805) 982-4207
62765N	Development of a Navy Energy Self-Sufficiency Plan/Demonstration Provide guidelines to Navy installations for selection, identification, and integration of alternative energy sources.			
64710N	Solar Desalination Design and Testing Design, build, test, and evaluate a full-scale desalination system at a Navy site.	CEL	E. Swaiden	(805) 982-5978
64710N	Heat of Solution Air Conditioning Provide an engineering study and a working model of a solar-powered endothermic refrigeration system for Navy use.	CEL	E. Swaiden	(805) 982-5978
64710N	Handbook of Alternative Energy Systems Compile a digest of operational requirements, physical characteristics, and potential outputs of solar, wind, and geothermal energy systems.	CEL	W. Lorman	
65861N	New Geothermal Site Evaluation Evaluate the geothermal potential of promising Navy sites through detailed analyses and economic utilization studies.	NWC	C. Austin	(805) 939-2700

APPENDIX B

**INDUSTRY AND OTHER
GOVERNMENT R&D**

APPENDIX B

INDUSTRY AND OTHER GOVERNMENT R&D

This appendix highlights the major energy R&D accomplishments by industry and government agencies since April 1977 when the last progress report was issued. The appendix is organized by the Navy strategies of energy conservation, synthetic fuels, and self-sufficiency.

ENERGY CONSERVATION

Strategic Petroleum Reserve Oil Purchases

DFSC handles the purchase of oil for the SPR program, which involves stockpiling about 500 million barrels of oil by 1982. (The Carter Administration is pushing for an accelerated program that would result in a 500 million barrel stockpile by 1980, however.) Under the terms of the interagency agreement, DFSC conducts government-to-government negotiations in purchasing the oil, and is responsible for performing all phases of contract administration, including scheduling and ordering, inspection and quality assurance, auditing, paying contract obligations, and resolving disputes or protests that may develop as a result of negotiating or administering the contracts. FEA is responsible for providing DOD with purchase requests for the crude oil. These requests detail specifications, quality, and delivery time-tables. FEA is also responsible for program budgeting and for requesting from Congress the appropriations for buying the oil. FEA advances funds to DOD to cover DFSC's salaries and administrative costs and to cover payments for petroleum and ocean transportation contracted by DFSC. (The first oil shipments arrived this summer.) This arrangement does not preclude FEA from conducting its own agreements with foreign countries for additional supplies.

Insulation Tests

Nineteen brands of cellulosic insulation were tested in April by ERDA, with support from the Naval Weapons Support Center in Crane, Indiana. The results of the tests could be of great importance, since the Administration's proposed energy policy stresses energy conservation measures in residential and commercial buildings.

Several of the brands tested were found to be lacking in some important areas of safety and performance. The study showed that, in 13 of the 19 samples, some separation of the fire-retardant chemicals from the cellulosic matrix occurred after handling under normal conditions, 6 of the 19 samples exceeded moisture-absorption criteria, and 6 of the samples supported fungal growth when tested in 86°F and 95 percent relative humidity for 28 days. In addition, thermal conductivity values for 7 samples exceeded values reported by the manufacturer, and 11 of the samples produced excessive corrosion of aluminum, copper, and steel when the insulation was contacted with water. ERDA stated in the report, however, that cellulosic insulation exhibits good thermal resistance in general, is manufac-

tured from inexpensive and readily available waste material (paper), and requires little energy or petroleum-based materials in its manufacture. As a result of the tests, ERDA is considering a reevaluation of performance criteria of cellulosic insulation.

Heat Pump Storage System

A pilot energy storage project that may enhance both the economics of heat pumps and effective load management by utilities was started in May by the Pennsylvania Power and Light Company (PPL). Usually, heat pumps require a supplemental heat source, such as resistance heating. The PPL concept uses a hot-water storage system in conjunction with a rooftop heat pump, which provides the supplemental heat. The system was installed on a 15,000-square-foot commercial building in Quakertown, Pennsylvania. The water in the storage tank is heated by the heat pump during the night, using cheaper base-load power instead of more expensive daytime peak-load power. The heated water is pumped through the building's pipes when supplemental daytime heat is required. According to PPL officials, a 450-gallon storage tank retains enough energy to heat the building for up to 9 hours. The Quakertown system is expected to cost about \$4,500 and save from \$165 to \$500 per month in heating costs, depending on the seasonal heating demand. Although installation is nearly complete, operational data cannot be obtained until the next heating season.

Compressed Air Energy Storage

Depleted oil and gas fields may be used to store compressed air that would be used during peak electricity demand periods to drive electric generators. The California State Energy Commission is studying this energy storage technique for DOE. The electricity generated during low-demand periods would be used to compress air, which would be stored underground and released during peak-load hours to drive a turbine generator. The California Commission's research staff feels confident that this is a promising energy storage technique and that it is closer to commercialization than other energy storage methods. Researchers are studying California's depleted oil and gas fields for possible energy storage use. A conceptual design for a pilot plant at one of the chosen sites will be developed and the environmental, social, and legal impacts of the system will be analyzed.

Chlorine-Zinc Storage Battery

Development of a chlorine-zinc storage battery that may have application for utility load leveling was announced in June by Energy Development Associates (EDA), a joint venture of Gulf and Western Industries, Inc., and Occidental Petroleum, Inc. The chlorine-zinc battery has its own heat exchanger and electrolyte pump, as well as a tank to safely store chlorine in the form of solid chlorine hydrate. Only a small amount of gaseous chlorine is present when the battery is in operation. EDA claims that this battery offers twice the efficiency of a lead-acid battery at about the same cost, but at much less weight. Also, the batteries are expected to last 50 to 60 percent longer than conventional lead-acid batteries. The presence of chlorine gas represents a potential safety problem, however. Officials of EPRI, which has been partly funding research on the new battery for several years and has just signed a \$3.9 million 39-month contract with EDA for further study, stated that proper

design of the battery will help resolve the safety questions by ensuring the absorption of excess chlorine gas. EDA expects to produce the new battery in large sizes for utilities, which would use it to store electricity that would otherwise be wasted during hours of off-peak load. EDA also wants to license other battery manufacturers to produce the chlorine-zinc battery in smaller sizes suitable for electric vehicles and other smaller scale applications. Widespread adoption of the battery will take at least 5 years, EDA officials said.

Domestic Hot Water Heating

Two contracts to develop domestic hot water heating systems that use heat pumps instead of resistance heaters have been awarded by Oak Ridge National Laboratory (ORNL). ORNL provides technical direction for DOE's appliance program. One contract is for the development of a heat pump for domestic hot water based on a fairly conventional Rankine cycle heat pump. The other contract is for the development of a system based on a novel open-cycle Brayton heat pump, which is yet to be designed. ORNL officials stated that if the open-cycle Brayton heat pump is developed successfully, its applicability could be more widespread than the Rankine concept.

Lube Oil Recycle Process

A new solvent and distillation process for reclaiming engine lube oil was developed by ERDA and tested in a 10-month fleet test by Iowa State University. No abnormal wear or performance was observed. In the process, the used oil is heated to drive off volatile hydrocarbons and water. A proprietary solvent system is added to remove a large portion of the contaminants as sludge. The desludged oil is subjected to conventional lubricating oil steps, such as distillation, color and odor improvements, and reformation with additives. The new process reportedly yields purified oil at high recovery rates without producing polluting by-products associated with the commercial acid-processing technology now used to reclaim lubricating oil.

Estimates show that about 1.1 billion gallons of lubricating oil are used annually in the United States, much of which could be recycled with efficient processing technology. Legislation would be needed, however, to discourage indiscriminate dumping and encourage effective collection of oil. Of the total waste oil generated annually, 480 million gallons are burned as a fuel supplement for boilers, 90 million gallons are rerefined to lube oil, and 200 million gallons are used in road oil and asphalt. The disposition of 340 million gallons is not known.

Motor Oil Rerefining Process

A new process to rerefine waste motor oil into a high-quality product comparable to virgin motor oil was developed by Phillips Petroleum Company. Higher grade oil can also be produced by blending the rerefined oil with additives. According to Phillips, the process is faster, more economical, and overcomes the environmental problems associated with other processes. Ninety percent of the oil can be recovered from motor oil waste using the Phillips 3-hour rerefining process. Other processes have been able to recover only 55 to 75 percent of the oil in waste. Environmentally, the Phillips process alleviates waste-disposal problems.

The waste remaining after oil removal is in a solid form that is safe for landfills or other uses. The wastewater from the process can be discharged into waterways or municipal sewage systems.

A plant using the new oil-rerefining process will be built by Phillips in Raleigh, North Carolina. The \$1.4 million plant, expected to start operation in mid-1978, will have a capacity of nearly 2 million gallons of waste oil annually.

SYNTHETIC FUELS

Multimineral Oil Shale Process

Superior Oil Company announced in April a process, researched and developed during a 10-year program, for economically producing oil from oil shale in the Rocky Mountains. Three minerals—raw nahcolite, alumina, and soda ash—are also produced in the process. An official of the company described the process as a four-stage operation: (1) mining the shale; (2) recovering nahcolite through secondary crushing and photosorting; (3) retorting the oil shale and leaching alumina and soda ash from the spent shale; and (4) returning the waste to the underground mine.

Superior developed the oil retorting process for a new circular grate retort; the retort was patented by McDowell-Wellman Engineering Company. One module, expected to cost \$270 million, would process 28,000 tons of oil shale per day and yield 13,300 barrels of oil, 4,500 tons of nahcolite, 700 tons of cell-grade alumina, and 1,500 tons of dense soda ash. A Superior official stated that the oil could be produced for \$10 to \$15 per barrel, assuming credits for revenues from the other products. Raw nahcolite is a desirable secondary product; it has been tested as a dry scrubbing agent for flue gases and will absorb nearly 100 percent of the sulfur oxides and up to 50 percent of the nitrogen oxides, under controlled conditions. Alumina, from which aluminum is made, could be extracted at a price competitive with alumina from foreign bauxite.

According to Superior Oil, engineering and construction of the module cannot be initiated until a land exchange has been completed with DOI. Although Superior owns 6,500 acres of contiguous oil shale land in Colorado, the present geographical configuration of the land does not lend itself to efficient mining.

Occidental Oil Shale Development Plan

In April, Dr. Armand Hammer, Chairman and Chief Executive Officer of Occidental Petroleum Corporation, restated his company's plan to develop syncrude oil shale commercially, in testimony before the Senate's Energy and Natural Resources Subcommittee on Energy Research and Development. Occidental's plan includes federal government funds to construct a 200,000-barrel-per-day plant in Colorado for \$1 billion. The plant, government owned and privately operated using Occidental's modified in-situ process, would produce syncrude at \$9 to \$15 per barrel; it would begin operating in about 5 years. The government outlay would be phased during construction, and the investment would be repaid by

revenues generated from the sale of the syncrude. At the same time, Occidental proposes that the government institute a plan to lease competitively nine additional tracts, each capable of producing 200,000 barrels per day. Thus, one company could not dominate the field because federal law limits any one company from leasing more than an aggregate of 5,120 acres of federal land. Also, Occidental proposes to license private companies at a 3 percent fee for use of the in-situ technology.

Dr. Hammer added that his company has completed a fifth retort, the second of commercial size. Also, he indicated that negotiations will resume shortly between Occidental and ERDA to fund a \$40 million cost-shared test project to develop advanced oil shale technology.

Occidental Tests of Fifth Oil Shale Retort

Recovery of shale liquids from Occidental Petroleum Corporation's fifth test retort began in mid-May. The retort, which uses the modified in-situ process, was ignited on April 18 and reportedly is performing according to plan. The retort, 120 feet in diameter and 250 feet high, is the second one tested using an improved mining scheme to reduce development costs. The fourth retort, which used the same design as the fifth retort, produced about 30,000 barrels of shale oil. However, because of inadequate rubblization of the lower strata of the chamber, the shale liquid yields were not high enough to confirm commercial viability of the retort design. Occidental officials are confident that rubblization in the fifth retort is complete, based on tracer test data. If the test is completed successfully, it would contribute in establishing the technical and economic feasibility of Occidental's modified in-situ process for shale oil development.

Shale Project Contract

ERDA signed an agreement with Equity Oil Company, Salt Lake City, for development of an underground in-situ shale oil extraction method. The joint project, in which the government will contribute \$5.5 million of the \$6.5 million cost of the program, is aimed at eventually developing the nearly 2 trillion barrels of oil from shale deposits in Colorado. Equity Oil will conduct laboratory and field tests over a 55-month period to determine the feasibility of injecting superheated steam through the entire vertical thickness of the "leached zone" formations in the Colorado Green River shale deposits.

ERDA also negotiated similar development contracts for in-situ recovery projects with three other companies: Geokinetics Oil Shale Group, Occidental Oil Shale, Inc., and Talley-Frac Corporation.

Shale Oil Project

Occidental Petroleum Corporation and DOE signed a cooperative agreement on a \$60.5 million in-situ oil shale retorting project. Under the terms of the agreement, DOE will fund 71 percent of the cost of the two-phase, 53-month effort. The first phase of the project, which will cost an estimated \$19.4 million, involves evaluation of two specific underground retort designs at Occidental's Logan Wash site in Garfield County, Colorado. In the second

phase, which will cost an estimated \$41.1 million, the design found superior in the first phase will be tested in a demonstration plant to determine its technical feasibility. The phase two demonstration plant, located on the Occidental-Ashland Oil federal Tract C-b in Rio Blanco County, will produce about 2,500 barrels of oil per day. In addition to demonstrating technical feasibility, DOE and Occidental hope to clarify the potential environmental hazards of modified in-situ retorting. This federally supported test is also expected to help give companies the incentive to develop a full-scale commercial program.

This award completes the series of four negotiations for the in-situ extraction of oil from western shale, which began with a program opportunity notice in February 1976. The three other awards went to Talley-Frac Corporation, Mesa, Arizona; Equity Oil Company, Salt Lake City, Utah; and Geokinetics, Inc., Concord, California.

IGT Shale Oil Output

The Institute of Gas Technology (IGT) announced the development of a second-generation hydroretorting process that could extract up to 35 percent more usable energy from Colorado shale than could the conventional thermal retorting process generally considered to be nearly ready for commercialization. The process could also increase yields in eastern shales by the same amount, according to Frank Schora, IGT senior vice-president. Eastern shales previously have been considered poor candidates for retorting feedstocks because they usually contain only about 10 gallons per ton on the Fischer Assay, whereas western shales generally contain 25 to 30 gallons per ton. The process could improve the economics of oil recovery from eastern shales by increasing yields. IGT is operating a \$1 million process development unit and hopes to begin building a pilot plant within 2 years. IGT hopes that DOE and the gas industry will participate in its program, since the hydrotreating process can be adjusted to yield mostly oil or mostly synthetic natural gas.

Oil Shale Development Project

Standard Oil Company of Indiana and Gulf Oil Corporation authorized the expenditure of \$93 million for a 5-year modular development program on the 5,100-acre, federal oil shale Tract C-a in Rio Blanco County, Colorado. Walter V. Herget, president of the Rio Blanco Oil Shale Project, stated that the project's detailed development plan was submitted to the Department of the Interior in May. The plan calls for a modified in-situ mining and processing technique that will result in intermittent production of shale oil over the 5-year period. Production levels are expected to be about 5,000 barrels per day.

The modified in-situ method to be used by Rio Blanco is a combination of sublevel caving methods with technology that is similar to in-situ recovery of heavy oil from sands. The mining technique involves drilling several vertical shafts, followed by rubblization of rooms by explosive charges placed in the shafts. The rubblized areas become underground retorts where the kerogen of the shale is separated from the rock by combustion, collected, and pumped to the surface. Eighty percent of the recovered oil is derived from underground retorting. An additional 20 percent, retorted at the surface, is collected from the ore removed before and during rubblization.

Herget said that, even if environmental problems are solved and economic conditions are favorable, full-scale production is not probable for at least 10 years. Rio Blanco has requested an extension of its lease suspension until the air quality problems can be solved.

Colony Oil Shale Project

The Bureau of Land Management completed the final environmental impact statement for the proposed development of the oil shale resources in northwest Colorado by Colony Development Operations. Atlantic Richfield is the operator for Colony, supported by a consortium of oil companies. The development plan involves right-of-way consideration for a 194-mile shale oil pipeline from the plant site at Roan Plato, Colorado, to Lisbon Valley, Utah. The environmental impact statement also assessed the import of the proposed development of an underground shale mine capable of producing 61,000 tons per day of oil shale for 20 years; construction and operation of a 47,000-barrel-per-day shale oil plant; construction of two dams and two power lines; diversion of water from the Colorado River; and exchange of 300 acres of private and federal land.

Shale as New Major Oil Source

Of the supplemental sources of liquid hydrocarbon fuels, oil shale is expected to be the only source to provide significant production by the end of the century, according to an interim study on long-range energy supply prepared by the ERDA and released in July. The conclusions of this study, the Market Oriented Program Planning Study (MOPPS), indicate, however, that shale oil production will be limited by the amount of water resources available in western areas for processing. The study also indicates that, although enhanced recovery techniques will be widely used in the next two decades, total oil production levels by 2000 will not be significantly higher than present levels because many wells will become depleted.

Gas will be supplied primarily by conventional sources through 2000, according to MOPPS. Unconventional sources of gas may begin to contribute to the U.S. supply by the end of the century if the major problems in conjunction with development of these sources are solved. The MOPPS also indicates that synthetic liquid from coal is not expected to have a significant market impact by 2000, and that electricity demanded from utilities will grow only about 3 percent per year through 2000 instead of the predicted 5 percent. This conclusion was based on the assumption that industry will take advantage of cogeneration and other means to produce their own energy, thereby reducing demand from utilities.

Gas from Devonian Shale Deposits

At least 240 trillion cubic feet of high-Btu gas may be recoverable from deep wells in Devonian shale formations in nine eastern, midwestern, and southern states, according to officials in ERDA's Eastern Gas Shales Project. This amount of gas is more than 10 times the nation's annual consumption of natural gas and equals the current proved reserves.

One goal of the Eastern Gas Shales Project, which has been under way for about 25 months, is to determine how much gas is actually in the formations. ERDA estimated that

there is a potential of 2,400 trillion cubic feet of gas in the shale formation. (The conservative estimate of 240 trillion cubic feet is based on the assumption that only 10 percent of the hydrocarbon potential will be recovered.)

Another goal is to devise new methods of production to attract developers. Although gas has been recovered from Devonian shale for over a century, large-scale drilling has not been done because of the typical lower production rates per well (200,000 cubic feet per day compared with 2 million to 5 million cubic feet per day for sandstone wells). Also, the need for research of new production methods, including fracturing of the shale by use of explosives or by hydraulics, has tended to hamper development. Project officials have stated that research is needed to reduce the cost of drilling in and recovering gas from Devonian shales, and to enhance the flow from the formations to increase recovery rates.

In-Situ Shale Oil Extraction Process

A \$12 million contract to develop a technology for in-situ shale oil extraction was awarded by ERDA to Talley-Frac Corporation, Mesa, Arizona. The Talley-Frac process calls for placing liquid explosives into wellbores to fracture the rock formation. Some of the shale oil is then ignited, thus liquefying and removing most of the remaining shale oil trapped in the fractured shale. With this process, environmental problems usually associated with oil shale processing can be avoided, according to Talley-Frac.

The 3.5-year program, including a 5,000-barrel-per-day demonstration plant to test the extraction process, will be conducted near Rock Springs, Wyoming, in the Green River formation in which 1.8 trillion barrels of shale oil are believed to be trapped.

Extraction of Oil from Sediment

Getty Oil Company is planning an open-pit mining project at McKittrick, California, to extract oil-impregnated diatomaceous sediments for conversion to syncrude. If successful, the project could add the equivalent of about 410 million barrels of in-place crude to national reserves.

Getty's development plans include starting up a pilot plant to evaluate the commercial feasibility and the environmental compatibility of the extraction process. If the pilot plant proves successful, full-scale operation will begin in 1982. There is an estimated 620 million tons of oil-bearing diatomaceous sediment in the field, with an average grade of about 28 gallons of crude per ton. Experiments showed that the crude would have a gravity of about 15 degrees after retorting. To date, no extraction process has been applied to produce syncrude from oil-bearing diatomaceous sediments on a commercial basis. Getty is confident, however, that certain techniques devised to extract syncrude from oil shale and tar sands can be modified to perform in a satisfactory manner on the sediment.

Exxon Estimates of Coal Liquid Prices

Exxon's donor solvent process can produce coal liquids for \$20 to \$25 per barrel, according to H. H. Goerner, senior vice president of Exxon Company USA, in testimony before

the Senate subcommittee on energy research and development. Goerner stated that one of the leading advantages of the donor solvent process is that it offers the flexibility to vary product mix from 25 to 50 percent gasoline, with the balance being liquefied petroleum gas, turbine fuel, and fuel oil. The Exxon official added that the process will produce between 2.5 and 2.7 barrels of liquid per ton of bituminous coal and about 2.3 barrels per ton of lignite. Exxon plans to build a 250-ton-per-day pilot plant, sharing costs with ERDA, EPRI, and Phillips Petroleum. The plant should be on stream in 1980.

General Electric Gasification Tests

Shakedown tests were conducted at General Electric's pilot-scale coal-gasification plant. According to General Electric, the \$3.1 million installation will gasify all types and grades of coal without pretreatment. In the test, the plant converted 1,500 pounds of low-grade coal per hour into 100,000 cubic feet of low-Btu fuel gas. This gas has a heating value of about 160 Btu per cubic foot, about one-sixth as much heat energy as found in an equivalent amount of natural gas. General Electric considers the low-Btu gas to be economically attractive for producing electricity.

Extraction of Methane from Coal Mines

A new demonstration project to extract methane gas from coal seams was announced in May by ERDA. The government hopes to recover the methane, which occurs naturally in many coal deposits and is similar to natural gas, for use as a commercial fuel. BOM experts have estimated that the amount of methane gas trapped in coal deposits in the United States is roughly equal to the total of known U.S. gas reserves. In recent years, BOM has experimented with techniques for draining methane from coal seams before mining operations begin. To date, technical and economic problems have hampered efforts to recover the methane as a commercial fuel. If the new approach is successful, vast reserves of methane could be used. The coal-derived methane could provide up to 5 percent of the nation's recent annual production of natural gas, or about 1 trillion cubic feet per year. Government spokesmen indicated that industry will be solicited to join in a 3-year methane recovery demonstration project.

Sulfur-Removal Process

High-gradient magnetic separation is being used to remove virtually all inorganic sulfur and 40 percent of the ash-forming materials from liquefied coal. Scientists at the Francis Bitter National Magnet Laboratory (NML) are performing the work under a grant from the National Science Foundation. NML scientists claim that using this process in conjunction with other coal-liquid refining techniques may enable the processing of much of the high-sulfur-content eastern U.S. coal without violating air pollution standards. In the process, pulverized coal is mixed with an inorganic solvent and heated to above 800° F in the presence of hydrogen gas. About 50 percent of the sulfur combines with the hydrogen, which is removed as a gas. Particles of clay and shale, which form ash, and inorganic sulfur bound to iron pyrites are removed by the magnetic separator. The magnetic separator is a water-cooled solenoid surrounding a canister of steel wool. The magnetic field generated by the solenoid varies in intensity at different points in the canister. Liquefied coal is fed

through the steel wool, where the impurities are trapped. Then the lighter parts of the liquid are removed and recycled as the solvent. The heavier parts are cooled and solidified and form the purified coal product. NML scientists estimate that another year of laboratory testing will be necessary before constructing a pilot plant using the magnetic separation process. Commercial feasibility of the process will depend on the economics of producing liquefied coal products.

Small-Scale Coal Gasification

In May, ERDA selected two firms to begin contract negotiations for the design of demonstration plants to convert coal to low-Btu fuel gas. The gas would be used for small-scale industrial processes. One of the companies selected, Erie Mining Company, will use Woodall-Duckham gasifiers to convert 500 tons of high-sulfur coal per day to gas to heat iron-ore pellets in the company's taconite plant at Hoyt Lakes, Minnesota. New Jersey Zinc Company, the other firm, plans to gasify 300 tons of high-sulfur coal per day at its Palmerton, Pennsylvania, plant. The gas derived will be used in a zinc smelting and refining operation.

Hygas Demonstration Plant

A contract for the design of a coal gasification plant to demonstrate the Hygas process was negotiated in June between ERDA and Procon, Inc., an architectural and engineering unit of UOP, Inc. The proposed agreement calls for Procon to prepare a conceptual design for a commercial-size Hygas plant that would produce 250 million cubic feet of high-Btu synthetic gas per day. The company will also prepare design and economic evaluations for a demonstration plant of about 75 million cubic feet per day.

The Hygas process was developed jointly by ERDA and IGT. In the process, coal is reacted under high pressure with hydrogen-rich gas to produce methane in a hydrogasifier. (IGT has been operating a Hygas pilot plant, with a capacity of 1,500 cubic feet per day, for about 4 years.) ERDA will pay for the conceptual design phase of the Hygas demonstration plant, which is expected to cost \$15 million to \$25 million. The second and third phases of the demonstration program—that is, construction of the plant and operation and evaluation—will be done on a 50-50 cost-sharing basis. ERDA spokesmen estimate that construction of the demonstration plant will cost \$200 million to \$300 million.

Gasification of Lignite

A 16,000-ton sample of lignite is being excavated from a 30,000-acre site in Texas by Exxon Company USA. It is the first lignite Exxon has mined in Texas, and because the characteristics of lignite vary widely, tests need to be performed to determine whether the lignite from the Texas site can be gasified successfully. The sample will be mined by mid-September and shipped to the SASOL plant near Johannesburg, South Africa, for commercial testing. Studies of the test data are not expected to be completed before 1979. Although the final decision will not be made before the completion of the test, Exxon is considering erecting a gasification plant on the Texas lignite field.

Synthane Pilot Plant

The Synthane gasification pilot plant reached a major milestone during August; it operated at controlled conditions for long periods without interruption. The plant, owned by ERDA and operated by The Lummus Company of New Jersey, produced gas for 190 hours during an 11.5-day run. Using 465 tons of western subbituminous coal, the Synthane plant produced 19 million standard cubic feet of dry raw gas. The best results were obtained during a 98-hour period of the test run when the gasifier temperature was held at 1,500° F, the coal feed rate averaged 2.2 tons per hour, and gas conversion averaged 73 percent. The run concluded the test program for Montana rosebud subbituminous coal. Enough data have been obtained for use in designing a Synthane demonstration plant for western coals.

DOE Coal Gasification Tests

DOE began a major test of an underground coal gasification experiment near Hanna, Wyoming, in October. Testing of the linked vertical-well technique being used in this experiment began at the Laramie Energy Research Center in March 1973. In three early experiments, the wells were spaced 60 feet apart. In this fourth and largest test, there are three 330-foot wells, penetrating a 30-foot thick coal seam, with 100 feet between wells one and two, and 150 feet between wells two and three. The coal in the seam will be ignited and air will be injected to maintain the burn. The burning of a portion of the coal in the seam will supply the energy necessary to pyrolyze the remaining coal, generating gas. DOE officials expect a maximum production of 25,000 million cubic feet of gas per day, based on the test results of the three previous experiments.

Gulf Studies of Coal Gasification

A process for gasifying coal in seams that cannot be mined using a present technology will be developed by Gulf Research and Development Company under a cost-sharing contract with DOE. DOE will contribute \$12.75 million and Gulf, \$1.5 million.

An estimated 100 billion tons of coal in the United States are in seams dipping so steeply that the coal cannot be mined with present technology. Gulf expects that about 25 billion tons of that coal can be burned in-situ to produce a low-Btu gas (150 Btu per cubic foot) for commercial use. The first phase of the 5-year project—selection of a site in either Colorado or Wyoming and preliminary environmental assessment—began in the fall; site characterization and field development will start in summer 1978. Field operation and testing will be done through 1980, with large-scale tests of the process scheduled for 1981. The final stage will be preparation of preliminary design and cost estimates for a pilot-scale project that would include surface facilities for processing the gas for commercial use.

Nation's Largest Coal Gasification Plant

The nation's largest low-Btu coal gasification plant was dedicated in November by Combustion Engineering in Connecticut. The \$25 million plant consumes 5 tons of coal per hour to produce 890,000 standard cubic feet of gas with a heating value of 100 to 125 Btu per

cubic foot. The atmospheric-pressure, entrainment gasification plant uses much of the standard equipment and systems employed by conventional coal-burning plants in producing a clean fuel. In Combustion Engineering's two-stage process, coal and char are injected into the gasifier and burned at temperatures over 3,000° F. The gases produced rise through the reductor and gasify additional coal. The gases are then cooled and cleaned. Sulfur, removed from the product gas by washing, is converted into commercial-grade elemental sulfur. Char and ash are also removed from the gas. Char is recycled to the combustor to guarantee maximum carbon utilization, and ash is removed as molten slag from the bottom of the combustor. The slag is dampened, ground, and dried for disposal in landfills.

Methanol as a Major Fuel

Methanol is expected to become a major industrial and commercial fuel in the 1980s, according to a study prepared by Roger Williams Technical and Economic Services, Inc., and the Charles A. Stokes Consulting Group. The report indicated that methanol will likely be used first by utilities then by industry. Methanol can be made from almost any organic compound, including coal, natural gas, and cellulose; can be easily shipped and stored; and is pollution free when burned. The cost of producing methanol commercially will probably be less than the cost of producing liquefied natural gas and synthetic natural gas, which is now about \$4 per million Btu. According to the report, when costs are lower, methanol could be used in ways not now considered cost-effective such as conversion to gasoline, rather than gasoline blending.

Peat as an Energy Source

Recent R&D has shown that peat could be an important fuel for electric power generation through a process known as wet combustion. Techniques for gasifying peat are also being evaluated. IGT reported in October that gasifying peat is both easier and less expensive than gasifying lignite or subbituminous coal. Furthermore, results of an economic analysis indicate that, at an initial estimate of \$2 per million Btu, peat compares favorably with conventional energy sources.

The United States has known reserves of about 120 billion tons of peat that, if converted, would yield 1,440 quads of energy. At least 42 states have peat deposits and, with the exception of Alaska, which has about 51 percent of U.S. peat reserves, most states have no other large, indigenous energy source. According to DOE officials, peat has several desirable qualities. It has a low-sulfur content, for example, and its extraction usually improves the agricultural value of the land. On the other hand, peat is bulky and has a high water content (around 90 percent). Since it would therefore be uneconomical to transport, peat would have to be converted on site.

North Carolina and Minnesota, both of which have large peat deposits, are conducting R&D of peat as an energy source for use commercially. The North Carolina Electric Membership Corporation, which consists of 28 electric cooperatives in the state, is planning a 150 MW electric power plant to be fueled by the direct combustion of peat harvested around the plant site. Minnesota, with the largest reserves in the lower 48 states, is studying peat gasification. The Minnesota Gas Company is working with DOE and IGT to develop a

process for converting peat into pipeline-quality gas. Laboratory results have been promising; conversion rates and methane yields have been high.

Proposed Syncrude Entitlements

Synthetic fuels derived from oil shale, tar sands, and coal should be included as eligible feedstocks under the domestic crude oil entitlements program, according to an FEA proposal, released in August. FEA's recommended amendments to the entitlement regulations provided that shale oil and other synthetic fuels be defined as crude oil substitutes and that they be treated the same as all oil, which is exempt from price controls. Thus, in calculating their entitlements eligibility, refiners could add the volume of crude oil substitutes to the amount of oil presently eligible under the entitlement program. Extension of the entitlement program to synthetic crude affords refiners who use shale oil the cost-equalization benefits now available to refiners using other, higher priced fuels.

A June 1976 FEA ruling established that, because they are not a commercially viable petroleum resource, synthetic fuels did not fall within FEA's authority to set mandatory petroleum allocation and price regulations. Since then, FEA has determined that several refiners are purchasing or contemplating the purchase of synthetic fuels for refinery feedstock. Refiners have also indicated to FEA that crude oil substitutes are not likely to sell at world market prices unless they are made eligible under the entitlement program. Based on this information, FEA decided to recommend removal of this price restriction on synthetic fuels in anticipation of greater availability and desirability of syncrude substitute.

Natural Gas from Geopressured Zones

From 250 trillion to 100,000 trillion cubic feet of natural gas may be recoverable from geopressured zones, according to government estimates. (The lower figure would more than double U.S. known reserves.) Geopressured zones are geological regions of high heat and pressure thought to contain natural gas and water at temperatures up to 300° F.

Osborn, Hodges, Roberts, and Wieland, an engineering firm under contract to DOE, began tests to determine whether gas contained in geopressured fluids can be recovered economically, whether the fluid can be used to supply hot water for industrial processes, and whether the hydraulic pressures can be used to generate electricity. This firm reopened an abandoned gas well in southern Louisiana as the first part of a phased study. Flow from the well began May 22, and initial tests of the fluid were conducted. It is not yet certain whether the trapped gas can be recovered economically.

SELF-SUFFICIENCY

Government Water Heating Program

In an effort to stimulate market demand for solar hot water heaters, ERDA announced in April a \$10 million cost-sharing program to use off-the-shelf hardware to install solar hot water heaters. The program should affect up to 10,000 homeowners, plus many multiunit

dwellings such as hotels or motels; both may apply for a grant or contract to pay partial installation costs. Although all the money is coming out of ERDA's budget, the \$10 million will be divided evenly between residential and commercial programs. The Department of Housing and Urban Development (HUD) will administer residential applications and ERDA will supervise commercial applications. Grants will be offered to residential and commercial owners in the 10 states that had the highest electrical rates last year; this involves northeastern states and Florida. In the past, the limited size of the solar equipment market has been blamed for keeping solar heating costs high. ERDA hoped this financial stimulus would give the essential market boost, since solar energy is close to being competitive economically with electric heating.

Sun-Tracking Heliostats

The sun-tracking mirror array of a solar thermal-conversion power plant was successfully tested in June at an estimated 1.7 MW capacity. Tested at Sandia Laboratories, the heliostats or mirrors focused the sun's energy onto a 6-foot-diameter area on a steel target, which simulates a boiler of the solar "power tower" electrical conversion concept. Temperatures exceeded 3,000°F. The Sandia facility will be used to test boilers for a 10 MW electric power plant in Barstow, California, that is expected to begin operation in the early 1980s.

Photovoltaic Conversion Material

New materials that can convert sunlight and heat directly into electricity have been developed, Stanford Ovshinsky of Energy Conversion Devices, Inc., announced in July. The new materials use amorphous semiconductors instead of crystalline silicon cells on which much of photovoltaic technology has been based thus far. (Crystalline silicon solar cells are somewhat difficult to produce and are relatively expensive; although researchers are attempting to lower the cost to between \$0.50 and \$2.50 per kW, the cells currently cost \$12.50 to \$20.00 or more per kW.) The amorphous materials developed by Energy Conversion Devices are combinations of such elements as oxygen, sulfur, selenium, tellurium, polycrystalline, boron, carbon, and silicon. The elements can be combined in a large variety of ways to produce the new conversion materials, and can be formulated for particular applications. Some formulations, instead of converting sunlight into electricity, could convert waste heat at temperatures as high as 500° C to electricity. Energy Conversion Devices hopes to produce the new materials in thin films for \$5.00 per square meter. If the efficiency of the system is 5 to 10 percent, as claimed, the cost would be less than \$0.10 per kW, according to Ovshinsky. The company hopes to have working solar converters available in 3 to 5 years.

On-Site Solar Conversion

Electricity produced from small on-site solar conversion units is closer to commercialization and may be more economical than power generated from large centralized solar facilities, according to a report released by the Office of Technology Assessment (OTA). The OTA report emphasized that small solar energy units (or on-site solar systems) to supply homes, apartment buildings, and commercial and industrial facilities must be regarded as "a serious addition to the limited number of options available for meeting the world's demands

for energy." The OTA project leader, Henry Kelly, said that small-scale solar electric technology is feasible both environmentally and socially, and will probably be competitive economically with conventional energy sources within 10 to 15 years. The researchers believe that small solar equipment could produce electricity for \$0.05 to \$0.15 per kWh. Therefore, if electricity rates increase by a factor of 1.5 over the next 20 years, there could be a large market where small solar conversion units would be attractive.

The OTA report examined applicability in four cities: Albuquerque, New Mexico; Boston, Massachusetts; Fort Worth, Texas; and Omaha, Nebraska. The results showed that, by 1985 in all four cities, combined solar heating and hot water systems could supplement conventional electric heat and heat pumps in residential and commercial buildings at competitive prices. Life-cycle cost analysis showed that, if a 20 percent investment tax credit were introduced, solar heating and hot water systems could be competitive today.

The study also analyzed two varieties of solar-electric conversion systems—photovoltaic cells and systems that heat fluids to operate heat engines that turn electric generators. Both approaches can be used to produce electricity alone or provide both electricity and heat in a total energy system. The study group contended that this was the major advantage of small solar units. The energy output of the system may be tailored to the particular requirements of the building by varying the ratio of thermal to electrical energy desired. The report concluded that federal policies to date have not adequately stimulated the adoption of solar equipment. The researchers noted that this could be corrected through federal legislation that would speed entry of solar equipment into the market, giving incentives to both the buyer and manufacturer.

New Photocell

A new and enlarged photovoltaic power cell capable of conducting more electricity through a solar array was developed by Solar Power Corporation, an affiliate of Exxon Enterprises, Inc. According to company officials, the new power cell will reduce the cost of solar photovoltaics by as much as 20 percent. The cell is designed for users with low power requirements that have no access to line power because of their remote locations. Typical applications would be radio repeater stations, microwave links, signaling devices, and water pumps.

The significant feature of the new cell is that it measures up to 3 inches in diameter, making it the largest photovoltaic cell on the market. By increasing the size of the cell, the incremental price differences between smaller and larger units, because of the cost of materials, is offset by increased power generating capability. Another factor that reduces cost is that the solar arrays can be assembled on the panels with greater ease than conventional solar panels because they have fewer parts. This can result in significant labor savings, and allows simpler fitting to specific installations. The company plans to produce solar arrays with 36 cells per panel, delivering between 25 and 31 watts of electrical power, for about \$800.

10-Megawatt Power Tower

A conceptual design was chosen in September for the nation's first experimental 10 MW solar power tower, which is expected to cost about \$100 million. The design, developed by a team headed by McDonnell Douglas Astronautics Company as part of a 2-year development program, is based on a cylindrical boiler (receiver), metal-glass mirrors (heliostats), and oil/rock thermal storage subsystems. DOE officials expressed confidence that this type of power plant can be built on a commercial scale by 1990 at a cost that should make it attractive to the electric utilities. The experimental plant will be built at Barstow, California, and will generate electric power by a solar-powered steam turbogenerator. Additional steam can be produced from the storage system to continue generating electricity for 4 hours without sunlight. In the concept chosen, the boiler/receiver sits atop a 283-foot tower and absorbs sunlight reflected from more than 1,500 mirrors surrounding the tower. These sun-tracking heliostats will be multifaceted glass mirrors of about 40 square meters.

DOE awarded contracts to fabricate components and construct the plant, and to place the plant in operation in late 1980 or early 1981.

Solar Collector Standards

DOE signed a contract with the Solar Energy Industries Association to institute a testing, certification, and rating system for solar collectors. The technical project officer for the contract stated that the 1-year, \$300,000 effort will result in a handbook detailing methods for testing solar collectors, as well as certification and rating standards. The project's aim is to build on work done on standards for solar collectors by HUD; the American Society for Heating, Refrigeration, and Air Conditioning; and others. The results will be used for all federal government programs involving solar collectors. The standards program will be developed and implemented by a committee comprising representatives of the solar industry, consumer organizations, the American Institute of Architects Research Corporation, and the American National Standards Institute. The work of the committee will be monitored by a federal oversight committee composed of representatives from DOE, HUD, NBS, NASA, DOD, and the Federal Trade Commission.

World's Largest Solar-Powered Air-Conditioning System

What is described as the world's largest solar energy cooling system was recently put into operation at a resort hotel in St. Thomas, Virgin Islands. The \$554,000 system, part of a DOE solar heating and cooling demonstration program, is designed to provide a large portion of the air-conditioning requirements for the 300-room hotel. The system includes about 13,000 square feet of flat-plate collectors that heat 450 gallons of water per minute to a temperature of 230° F. The heated water is used to drive a series of absorption type chillers to provide the necessary air conditioning. The hotel's proprietor expects to save approximately \$100,000 per year by relying on solar energy instead of the diesel fuel used previously. The solar cooling system does not have the capability of hot water storage; consequently, the conventional oil-fired steam system will not be phased out entirely. It will be used to run the air-conditioning system at night or during periods of heavy overcast.

Elimination of the energy storage capability was the most economic alternative, according to NASA's Marshall Space Flight Center, which designed and installed the system.

The Marshall Center, under a NASA/DOE agreement, is managing the technical design and installation of solar heating, cooling, and hot water systems at 59 sites in the United States as part of the DOE's commercial demonstration program. DOE provided 75 percent of the cost of the system at St. Thomas, with the hotel's owner supplying the remainder.

New Solar Concentrator

The California Institute of Technology developed a concentrating device that is said to double or triple the collection efficiency of silicon cells, when compared with the ground lenses currently used. The concentrator is a sheet of polymethyl-methacrylate infused with several different fluorescent dyes, such as rhodanine. Donor dye molecules absorb light outside the wavelength range that can be efficiently absorbed by the cells, and transfer this energy to acceptor dyes. These molecules then re-emit this transferred energy as light within the narrow wavelength band most efficiently used by the solar cells. Caltech claimed in January that the new concentrator can be produced for less than one-thousandth the cost of ground lenses and effectively concentrates light into an area about one-thousandth that of the lenses.

Solar Photovoltaic Costs

Solarex Corporation, Rockville, Maryland, will manufacture photovoltaic devices for the 250 kW demonstration installation to be built for DOE at Mississippi County (Arkansas) Community College, at a cost of \$4.75 to \$5.75 (1977 dollars) per peak watt. The cost is less than half that of photovoltaic equipment sold to date. For example, more recent procurement of photovoltaics by DOE, announced on December 5, called for an average price of just under \$11 per peak watt (1975 dollars). The major reason for the price decrease is that the Mississippi County College demonstration will use a concentrator type of solar panel that mechanically tracks the sun's rays. Concentrator arrays need only one-twentieth the number of solar cells per watt as do flat-plate arrays. Optical surfaces are less expensive than silicon cells. In the Solarex bid, the cost of silicon cells was set at about \$2.75 per watt, and at \$2 to \$3 per watt for the concentrator equipment. The federal government has set cost goals for photovoltaic equipment at \$2 per peak watt by 1982 and \$0.50 per peak watt by 1986 (1975 dollars).

Kelp Conversion

A major project to study the conversion of kelp to methane is being undertaken by General Electric in cooperation with the American Gas Association and IGT. IGT already is involved in biomass conversion projects using sewage, urban refuse, and farm products, and will conduct studies to determine the feasibility of converting kelp to intermediate-Btu gas in commercial quantities through an anaerobic digestion process. The kelp will be produced off the coast of California.

Vertical-Axis Wind Turbine

A seven-story, Darrieus, vertical-axis wind turbine began operation at the Sandia Laboratory. The turbine has a 55-foot-diameter rotor and is designed to produce 60 kW of electricity in a 28 mph wind, and 30 kW of electricity in a 22 mph wind. The vertical-axis design of the wind turbine reportedly offers cost advantages over the more common horizontal-axis, propeller-type wind turbines that have been tested. Officials have stated that the vertical-axis blades are easier and less expensive to build than the more common one-piece blades.

2,500 kW Windmill

The world's largest windmill, capable of supplying 2,500 kW of electricity, will be built during the next 2 years in a test program conducted by DOE and managed by NASA. The \$10 million wind turbine, with blades 300 feet in diameter, will be located near a utility company and will supply electricity to the utility grid for public use. The purpose of the project is to investigate the economics and operating characteristics of the large wind turbines when coupled with conventional power plants. The windmill will be designed for an area with an average wind speed of 14 mph. Boeing Engineering and Construction Company was chosen to design, build, assemble, install, and test the windmill.

Geothermal Areas in Eastern United States

Scientists have found potential geothermal energy sources near major urban centers in the eastern United States. These sources potentially may be tapped for heating residential and commercial buildings as well as providing industrial process heat, according to DOE. The Virginia Polytechnic Institute is doing the study under contract as part of a research project to locate hot water reservoirs that could serve as sources for space heating or low-temperature heat for industry.

The geothermal energy sources are heat-producing granite rock bodies underlying the eastern coastal plains at depths of about 1.5 kilometers. The heat is generated by the slow decay of natural radioactive material, which is common to all granites but is particularly abundant in eastern granite. The granite is covered with an insulating layer of sedimentary rock saturated with water, which stores the heat generated over millions of years.

Probable buried granitic heat sources have been identified near Savannah, Georgia; Charleston, South Carolina; Baltimore, Maryland; Norfolk, Virginia; and Jersey City, New Jersey. Temperature, depth, and productive capacity of these potential geothermal areas are being quantified. According to government officials, if the present studies continue to be promising, the most favorable sites will be drilled.

Mineral Recovery in Geothermal Development

The economic justification of geothermal energy development may be closely tied to mineral recovery as well as the efficient generation of electric power, speakers told a meeting of the American Institute of Chemical Engineers. C.D. Hornburg of DSS Engineers, Inc.,

outlined a plan for a geothermal energy and mineral industrial complex in southeast California near the Salton sea. He noted that there has been considerable R&D done on the recovery of energy from geothermal brines, but that relatively little work has been done on the recovery of minerals from these brines. An estimated 100 million gallons of geothermal brine per day, at 300° C, could generate, each year, about 4.5 billion kWh of electricity valued at \$135 million. In addition, according to Hornburg, minerals recoverable from the same quantity of brine would be valued at about \$75 million. Some of the recoverable minerals, such as iron oxide, soda ash, chlorine, sodium silicates, lead, salt, and manganese, could be upgraded by efficient use of geothermal energy to yield products of a substantially higher value.

Man-made Geothermal System

An experimental, man-made geothermal well system was created in the Jemez Mountains of New Mexico by scientists at the Los Alamos Scientific Laboratory (LASL). The LASL scientists created the system by drilling two holes about 2 miles deep and separated on the surface by about 250 feet. Water was injected under high pressure to fracture granite bedrock heated by volcanic activity. Fracturing resulted in the creation of a system of cracks in the granite bedrock, thus exposing a large heat-exchanging surface with a temperature of about 400° F. Cold water was then injected down one hole at 900 to 1,000 psi. As the water circulated in the crack system, it was heated to approximately 265° F. The heated water then flowed up the second hole to the surface. Back pressure was applied to the second hole so that the heated water would not flash until it reached the surface.

The major obstacle in developing the system was accurate mapping of the fractured zone to ensure connection of the two bore holes. Another potential problem is whether the injected water will be heated to sufficient levels of power generation if the injection is maintained over time. In tests conducted to date, water injection has been maintained for only 20 hours.

Installation of two 10 MW (thermal) heat exchangers will allow study of the feasibility of a closed-loop pressurized water system. The system will be operated for several months to determine whether circulation temperatures can be maintained at acceptable levels and whether precipitation of minerals, mostly silica, will adversely affect the system.

LASL scientists describe the potential of hot dry rock geothermal energy as enormous. There is an estimated 13 million quads of thermal energy in rock with temperatures above 300° F and less than 6 miles deep.

New Geothermal Area

A 19,000-square-mile region along the Snake River Plain and adjoining areas of southern Idaho will be explored to identify areas where geothermal steam or hot water might be used for generating electricity, space heat, and other applications. The 3-year effort to assess the geothermal potential of the area is being sponsored by DOE, USGS, the U.S. Forest Service, and the Idaho Department of Water Resources. According to USGS, the

abundance of young volcanic rocks and the widespread occurrence of warm springs and wells in southern Idaho indicate that there may be a large thermal anomaly beneath the plain.

Economics of Geothermal Steam Plants

Geothermal steam plants produce electricity at a lower cost than do oil, coal, or nuclear power plants, and the capital cost is lower, according to a study prepared in August by the Stanford Research Institute. The study showed that, in constant 1976 dollars, producing power with steam cost 20.4 mills per kWh, while using conventional oil cost 33.5 mills per kWh, low-sulfur coal cost 29.3 mills per kWh, and nuclear power cost 29.0 mills per kWh. A comparison of plant capital investment costs in constant 1976 dollars indicated that geothermal steam plants cost \$200 to \$280 per kWh. Costs of conventional oil and coal plants were estimated to range from \$350 to \$400 per kWh and nuclear plants from \$720 to \$830 per kWh.

Binary-Cycle Geothermal Plant

A \$42 million, 45 MW geothermal power plant that would be the largest of its type in the United States is being designed by Fluor Corporation to assist the San Diego Gas and Electric Company and its partners in their proposal for funding to DOE. Construction of the plant near Heber, California, by Fluor Corporation, is contingent on the receipt of federal and other funding.

Fluor officials stated that it is designing the proposed plant utilizing a relatively new approach for converting heat energy in geothermal brine to electric power. In this design, called a binary cycle, the hot brine is used to heat a working fluid, which is vaporized to drive a turbine. After passing through the turbine, the vapor is condensed and revaporized repeatedly in a closed-cycle operation. The corrosive brine therefore comes in contact with only a small portion of the plant machinery. The brine is reinjected into the geothermal reservoir for reheat, again in a closed-cycle operation. Fluor has noted that geothermal experts have estimated conservatively that the Heber geothermal resource area could support production of 400 to 500 MW of power. If this plant is completed and operated successfully, a number of additional geothermal electric generating stations would be built in the area, according to Fluor.

APPENDIX C
LEGISLATION

APPENDIX C

LEGISLATION

The first session of the Ninety-fifth Congress convened on 4 January 1977. After President Carter issued his National Energy Plan on 20 April 1977, increased emphasis on the passage of energy legislation held the attention of most members of Congress. During the first session of the Ninety-fifth Congress, many energy-related laws were passed, but some bills were carried over into the second session. The status of this legislation is described below.

NATIONAL ENERGY POLICY

Primary emphasis in the Ninety-fifth Congress has been placed on President Carter's comprehensive energy policy package. At the end of the first session, House and Senate conferees were still debating many issues. Conferees on the natural gas sections of the proposed National Energy Act reconvened on 23 January 1978 in an effort to resolve their differences over natural gas pricing and/or deregulation. After these differences are worked out, the conferees will work on the tax sections of the package, including the crude oil equalization tax and minimum energy conservation standards for automobiles. Utility rate reform, coal conversion, and energy conservation measures have already been resolved by the committee.

NATURAL GAS PRICE CONTROL

The Ninety-fifth Congress responded to the recent natural gas crisis by enacting legislation (P.L. 95-2) giving the President temporary authority, which expired 1 August 1977, to control natural gas prices and allocation systems. The National Energy Act contains a provision to extend the authority. However, proposals—ranging from total deregulation of natural gas prices to federal regulation of both inter- and intrastate natural gas—were still being debated as the second session of the Ninety-fifth Congress began.

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FY 1978 BUDGET REQUEST

The FY 1978 budget submitted by President Ford in January 1977 was revised by President Carter to reflect new priorities in energy R&D. P.L. 95-39, appropriating the FY 1978 budget, was approved 3 June 1977. Funding requests for conservation, fossil energy, solar heating and cooling, and environmental and biomedical research were increased, and those for solar electric, fusion power, and nuclear fuel cycles were decreased. P.L. 95-238, passed 25 February 1978, authorized the funds for energy R&D.

DEPARTMENT OF ENERGY

P.L. 95-91 established DOE to direct a coordinated national energy policy. The Federal Energy Administration, Energy Research and Development Administration, Federal Power Commission, and the energy-related functions of several other agencies were combined to permit coherent management of energy research, development, demonstration, commercialization, and regulation.

DEPARTMENT OF ENERGY FY 1979 BUDGET REQUEST

Hearings on DOE's proposed FY 1979 budget began in February 1978 before the Senate Appropriations Committee and in March before the House Appropriations Committee. This is the first funding budget for the newly organized DOE. Emphasis is on fossil and alternative fuels development, with increased support for solar, geothermal, and conservation programs.

SURFACE MINING AND LAND RECLAMATION

Legislation to establish the first national regulations for surface mining and reclamation has been a controversial issue. During the Ninety-fourth Congress, President Ford vetoed a surface mining regulation bill. Under President Carter, the bill received strong support and was passed 3 August 1977 to become P.L. 95-87. An Office of Surface Mining Reclamation and Enforcement was established within DOI to administer the programs to control surface mining operations.

CLEAN AIR ACT AMENDMENTS

Provisions requiring nondeterioration of relatively clean air areas and establishment of automobile emission standards were enacted by the Ninety-fifth Congress. To eliminate the economic advantage of delaying compliance with air quality standards, the Environmental Protection Agency and the states were given enforcement authority by P.L. 95-95.

NATURAL GAS PIPELINE

On 8 November 1977, the Congress approved the President's decision on an Alaskan natural gas transportation system. The private construction of a pipeline through Canada will permit the transport of Alaskan natural gas to the lower 48 states.

NUCLEAR PROLIFERATION CONTROL

The issue of controlling nuclear proliferation has become more complex as more nations develop nuclear capabilities. The proliferation of nuclear materials involves not only energy development, but also defense and international relations. President Carter has

strongly supported limited exportation of nuclear materials to maintain international stability. The recently passed Nuclear Nonproliferation Act became Public Law 95-242 on 10 March 1978.

AMENDMENTS TO THE OUTER CONTINENTAL SHELF (OCS) LANDS ACT

At the beginning of the first session of the Ninety-fifth Congress, a bill was introduced to reform the management and bidding procedures used by DOI to grant OCS oil and gas leases and to increase states' roles in OCS development. The legislation has received support from both the Carter Administration and representatives of the coastal states. Having passed both houses of Congress, the differences in the two legislative versions are being debated.

APPENDIX D

NATIONAL ENERGY POLICY
AFFECTING THE NAVY

APPENDIX D

NATIONAL ENERGY POLICY AFFECTING THE NAVY

The Administration's FY 1979 DOE budget submission to Congress contains budget and tax proposals that support much of the policy embodied in the National Energy Act still under consideration. If Congress fails to act on the National Energy Act, passage of DOE's budget would ensure at least partial implementation of Carter's national energy plan. The major provisions of the FY 1979 DOE budget request are:

- Energy conservation—to encourage the efficient use of energy in all forms, but particularly oil and natural gas; \$1.4 billion in outlays and \$1.2 billion in new tax expenditures.
- Energy supply—to encourage the development of additional energy resources and technologies that will increase production from domestic energy resources, particularly those that can substitute for increasingly scarce oil and natural gas; \$4.1 billion in outlays.
- Emergency energy preparedness—to develop the means to withstand disruptions in the supply of imported oil; \$3.3 billion in outlays.
- Energy information, policy, and regulation—to ensure that national needs with respect to energy are met in an efficient and equitable manner; \$0.9 billion in outlays.

The total FY 1979 budget authority for DOE is estimated to be \$12.6 billion, with budget outlays projected to be \$10.0 billion. The basic spending programs related to energy supply research and technology development are summarized in Table D-1.

**Table D-1. ESTIMATED FUNDING FOR ENERGY SUPPLY RESEARCH
AND TECHNOLOGY DEVELOPMENT
(Millions of Dollars)**

Program	FY 1978 Estimate		FY 1979 Estimate	
	Budget Authority	Budget Outlays	Budget Authority	Budget Outlays
Coal	\$ 579.1	\$ 520.1	\$ 618.2	\$ 609.4
Petroleum	74.1	62.5	79.7	73.7
Gas	31.0	26.5	25.9	30.0
Solar	302.7	225.2	309.2	281.4
Geothermal	106.2	81.9	129.7	118.9
Magnetic fusion	325.4	279.1	334.0	327.0
Fuel cycle R&D	284.9	212.8	247.4	227.7
Breeder reactor	517.1	610.6	367.4	445.0
Nuclear research and applications	226.7	206.8	278.5	253.8
Light water reactor facilities	28.1	24.6	10.0	19.0
International spent fuel storage	5.0	5.0	3.0	3.0
Hydroelectric	10.0	7.5	8.0	6.0
Fuels from biomass	20.7	15.2	26.9	15.3
Basic energy sciences	117.4	164.1	211.5	201.1
Advanced technology and assessment projects	7.5	5.7	21.0	17.0
Total	\$2,695.9	\$2,447.6	\$2,670.4	\$2,628.3