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SOLAR THERMAL POWER SYSTEMS

Program Summary

U.S. Department of Energy
Assistant Secretary for Conservation
and Solar Energy

December 1979

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Program Summary

Prepared by
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U.S. Department of Energy
Assistant Secretary for Conservation
and Solar Energy
Washington, D.C. 20585
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PREFACE

On October 26, 1974, the Solar Energy Research, Development and Demonstration Act (Public Law 93-473) was signed into law, authorizing a vigorous Federal program of research, development, and demonstration. Its goal was to provide the nation with the option of using solar energy as a new source for meeting future requirements. In response to the mandates of this act, major efforts were made within the Division of Solar Energy of the Energy Research and Development Administration (ERDA) to expeditiously develop and introduce economically competitive and environmentally acceptable solar energy systems.

These responsibilities were transferred to the newly organized U. S. Department of Energy (DOE) on October 1, 1977. Presently DOE's solar energy activities all come under the jurisdiction of the Office of the Assistant Secretary for Conservation and Solar Energy (CSE) and are divided into three distinct organizational components:

- Division of Central Solar Technology
  - Ocean Systems Program
  - Solar Thermal Power Systems Program
- Division of Distributed Solar Technology
  - Biomass Energy Systems Program
  - Photovoltaic Systems Program
  - Wind Energy Systems Program
- Office of Solar Applications
  - Market Testing and Applications Program
  - Systems Development Program
  - Program Management and Support Program

Program planning continues under the guidelines established by PL 93-473 and by three other legislative acts passed by the 93rd Congress: the Solar Heating and Cooling Demonstration Act of 1974 (PL 93-409), the Energy Reorganization Act of 1974 (PL 93-438), and the Federal Nonnuclear Energy Research and Development Act of 1974 (PL-577). Together these four laws grant DOE and other Federal agencies the authority to pursue a research program aimed at effective solar energy use. Under this authority, SOLAR/CSE is working to develop solar energy technologies and to complement efforts in the private sector to develop solar energy resources.

A program summary is issued for each solar program annually. Each summary provides an overview of the ongoing research, development, and demonstration efforts of the preceding fiscal year (FY).

This program summary describes each of the DOE's Solar Thermal Power Systems projects funded and/or in existence during FY 1979 (October 1, 1978 through September 30, 1979) and reflects their status as of September 30, 1979. This document is a follow-up to the FY 1978 Solar Thermal Power Systems Program Summary (DOE/ET0078 published in December 1978), which can be ordered from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.

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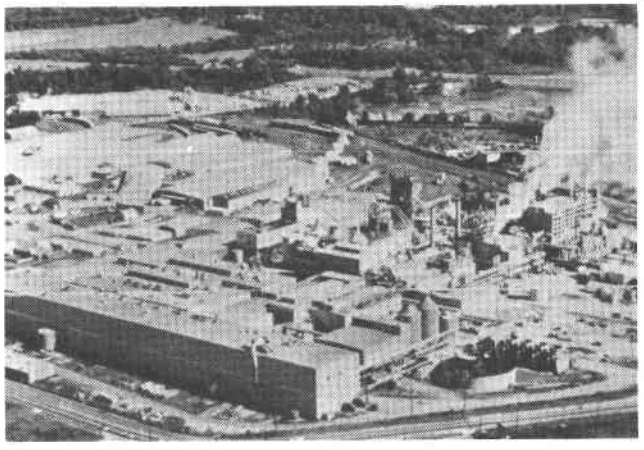
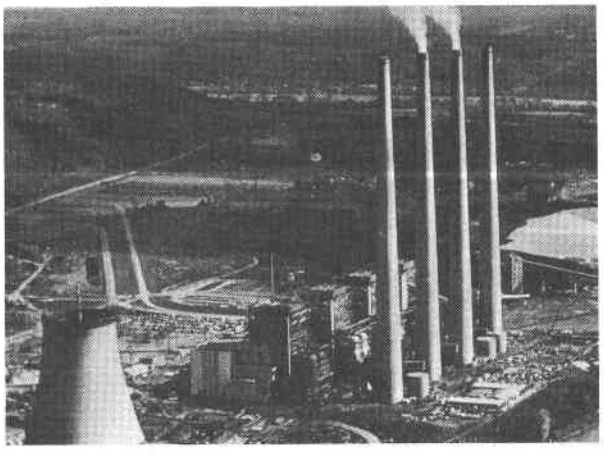
SOLAR THERMAL: A MEANS TO A NATIONAL GOAL

In his speech on June 20, 1979, President Carter committed the nation to an aggressive program to establish solar energy as a primary source for meeting the nation's energy needs. The goal he set is to displace 18.5 quads*/year of fossil fuel with solar energy, or roughly 20 percent of the projected yearly U. S. energy consumption, by the year 2000. Of this amount, the goal for solar thermal systems for the year 2000 is 3 quads/year (not including heating and cooling).

*1 quad = 10^{15} Btu.



Heat



Electricity

Fuels

Applications of Solar Thermal Energy

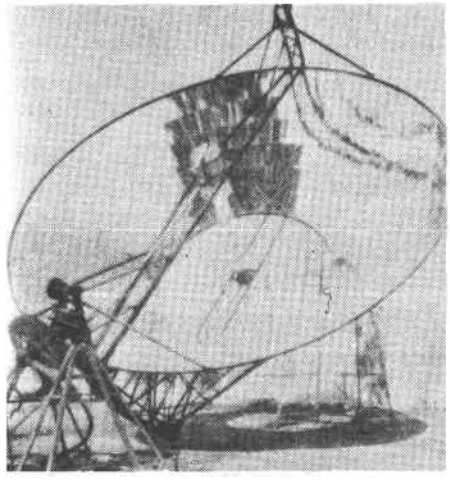
DOE SOLAR THERMAL PROGRAM ORGANIZATION

DOE Solar Thermal Program research, development, and demonstration activities are organized to focus on specific types of concentrator systems, all of which will have commercial potential. The program is organized into the following areas, each being further divided into sub-element areas:

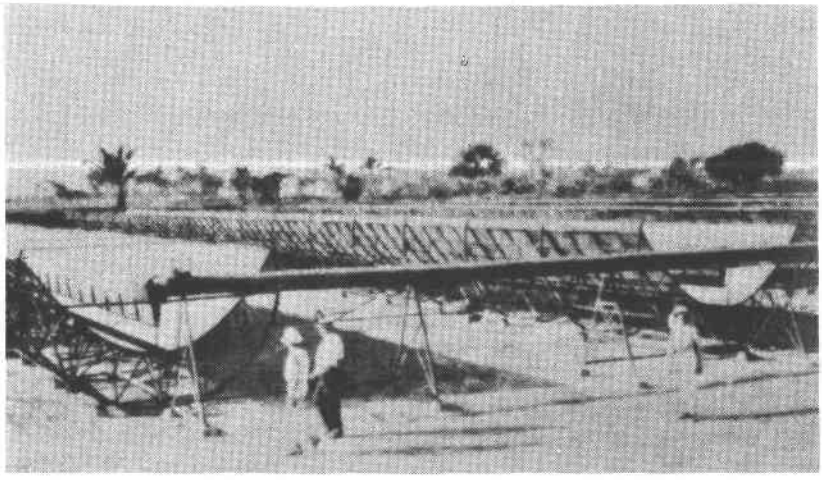
- Distributed Receiver Engineering Development
  - Line-Focusing Systems
  - Point-Focusing Systems
- Central Receiver Engineering Development
  - Systems and Applications
  - Subsystems and Components
- Advanced Technology
  - Material Technology
  - Advanced Subsystems
  - Advanced Systems/ Applications
  - Supporting Programs

FEASIBILITY OF SOLAR THERMAL TECHNOLOGY ESTABLISHED LONG AGO

The technical feasibility of concentrating solar thermal systems was established in the latter part of the 19th century. By the early part of the 20th century, such systems were being used to power small heat engines and irrigation pumps. A 33-ft. parabolic dish was operating at the Cawston Ostrich Farm in Pasadena, California in 1901. At Meadi, Egypt in 1913, a solar irrigation pump was producing an output of 50 hp. The present generation of parabolic dishes and troughs operate on the same basic engineering principles as these early versions, but have higher temperature capabilities and greater efficiencies, and feature mass-producible designs.



Parabolic Dish, Pasadena, California: 1901

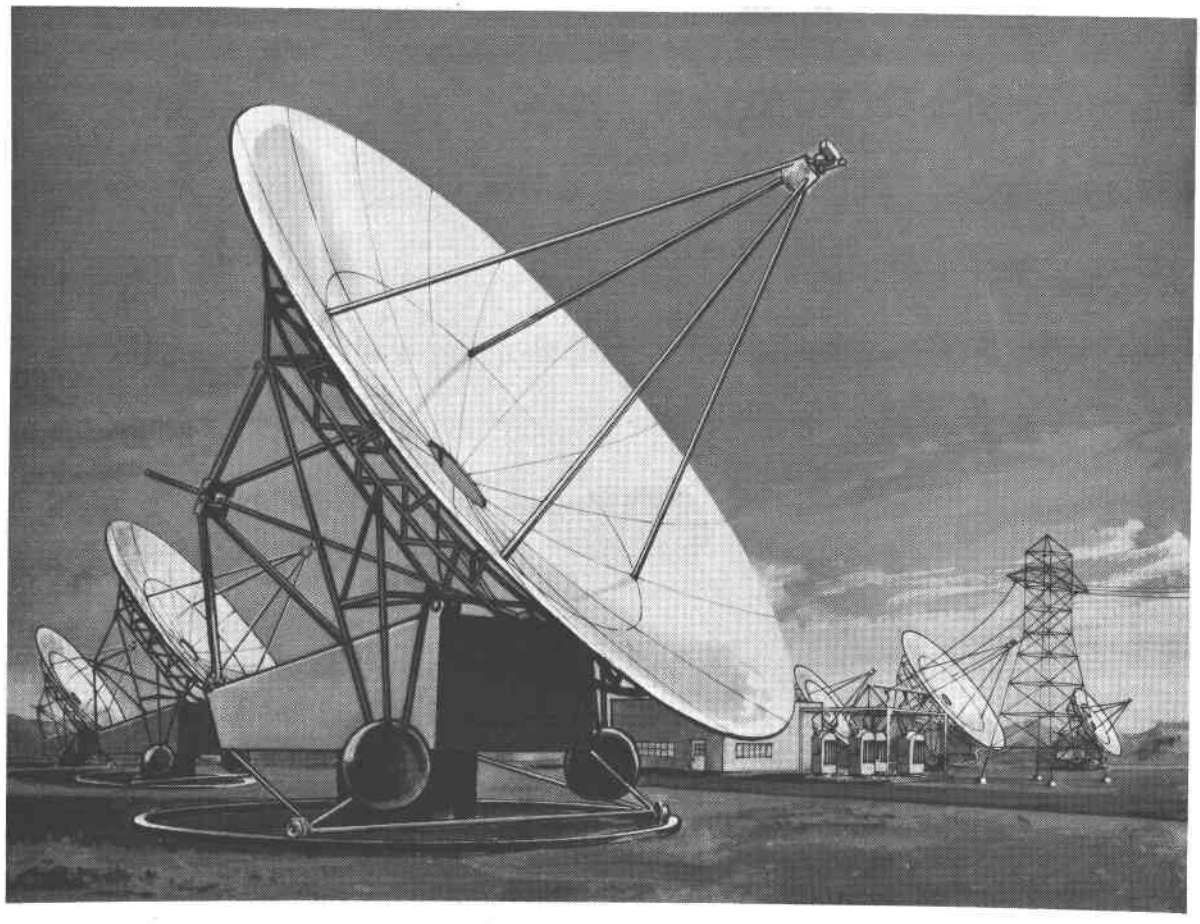


Parabolic Trough, Meadi, Egypt: 1913

POINT-FOCUSING, DISTRIBUTED RECEIVER PARABOLIC DISH CONCENTRATORS

Point-focusing, distributed receiver parabolic dish concentrators provide a technology development path which offers the highest possible optical performance, high-temperature capability (750 to 3,000 ^{o}F), minimum land use, and a high degree of modularity (tens of kilowatts to tens of megawatts). With these characteristics, dish systems are potentially the most versatile concentrator approach and are adaptable to many near-term markets for solar thermal technology, particularly electrical power generation in remote and community-scale applications.

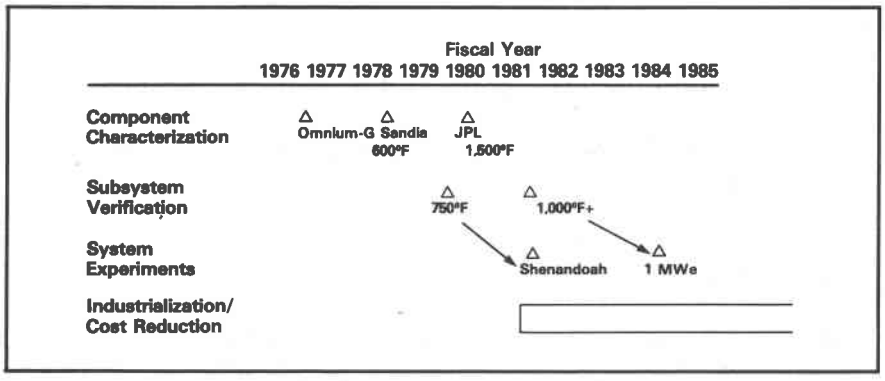
Dish development programs have produced several collector designs and supporting hardware. These designs are then fabricated with cooperation from the industrial sector. Field experimentation follows with the operational experience gained leading to lower costs and eventual commercialization. This technology development process is aided by technical and managerial support provided by the Jet Propulsion Laboratory in Pasadena, California. Parallel work to develop suitable materials, tooling, and automation techniques will ultimately ensure the mass-producibility of market-ready products.



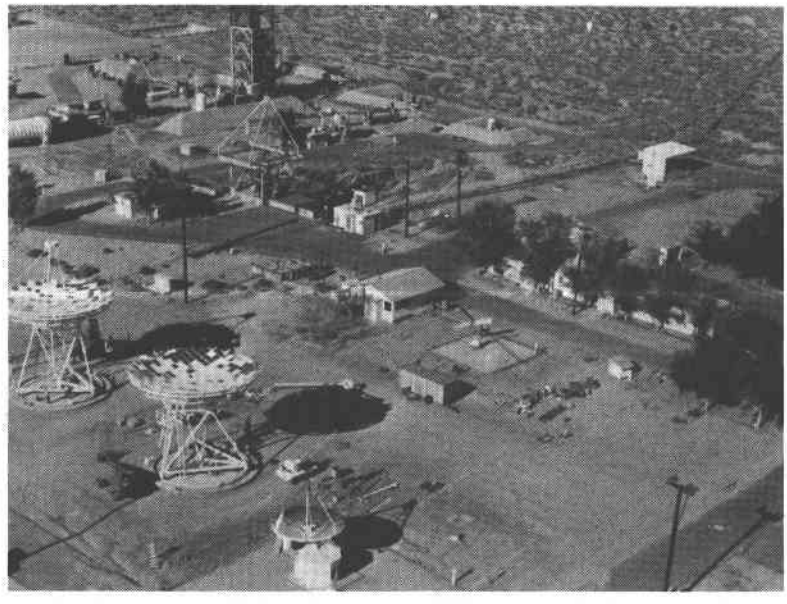
A parabolic dish concentrator focuses sunlight so that the heat can be collected by a mounted point-focus receiver.

PARABOLIC DISH SUBSYSTEM DEVELOPMENT AND TESTING

The Parabolic Dish Test Site operated by the Jet Propulsion Laboratory at Edwards Air Force Base, California, is being used to support the development of dish-mounted heat engine/generator and heat production modules. Planned capability is for 10-35 kilowatts-electric (kWe) per module and temperatures of between 1,000 ^{o}F and 2,000 ^{o}F. Currently, a commercial collector design by Omnium-G is under test at the test site along with two test bed concentrators developed by E-Systems. Prototypes of a 750 ^{o}F General Electric dish (for use in the Shenandoah, Georgia, Total Energy Project) are on test at Sandia's Mid-temperature Solar Systems Test Facility (MSSTF) in Albuquerque, New Mexico.



Distributed Receiver Dish Program



Parabolic Dish Test Site

FIRST GENERATION PARABOLIC DISH CONCENTRATORS

Omnium - G

The Omnium-G module is the first commercially available parabolic dish system. It is presently being tested at the Parabolic Dish Test Site (Edwards Air Force Base, California), the Solar Energy Research Institute ACRES test facility, the University of Houston, and the University of Seattle.

It will also be used at a Southern New England Telephone Company switching station to provide electricity and space heating and cooling in a total energy application.

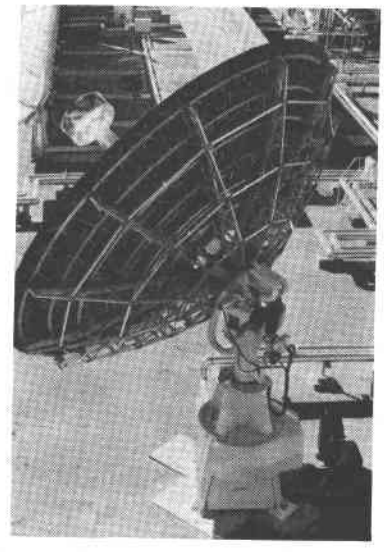
Raytheon

The Raytheon parabolic concentrator is 6.7 meters in diameter, with an effective aperture of 35 m^2. The mirrors are curved glass, hard mounted on an aluminum substructure; they concentrate the solar energy into a cavity absorber located on the collector optical axis.

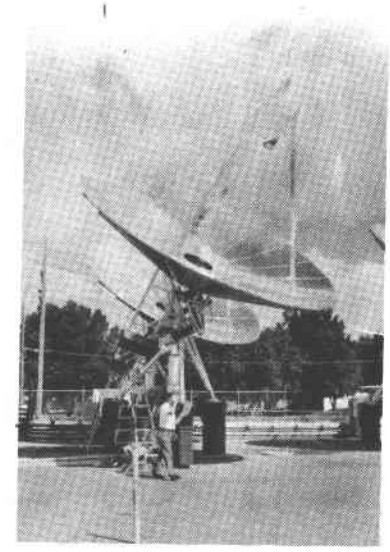
General Electric (GE)

The 7-meter GE parabolic dish has been selected for use in the Shenandoah Total Energy Large-Scale Experiment at a knitwear plant at Shenandoah, Georgia. Four prototype dishes are currently being tested at Sandia's Mid-temperature Solar Systems Test Facility to characterize their interaction.

The Omnium-G Dish



The Raytheon Dish

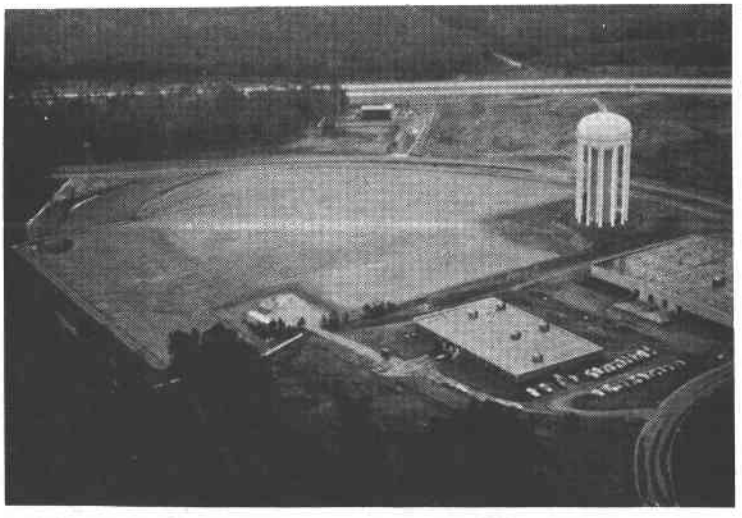


The GE Dish

SHENANDOAH TOTAL ENERGY SYSTEM EXPERIMENT

First-generation dish technology under development for near-term market opportunities is being used in a total energy system project at Shenandoah, Georgia. This experiment will use parabolic dishes operating at 750 °F to produce 400 kW of electricity, as well as low-temperature steam, for use at a knitwear factory. The knitwear plant's electrical and process heat needs will be combined into a single composite load to be served by the adjacent solar total energy system. In this way, the economic advantages of the solar system are enhanced, making near-term application of solar technology more viable.

GE Parabolic Dishes--to be used in the Shenandoah Experiment



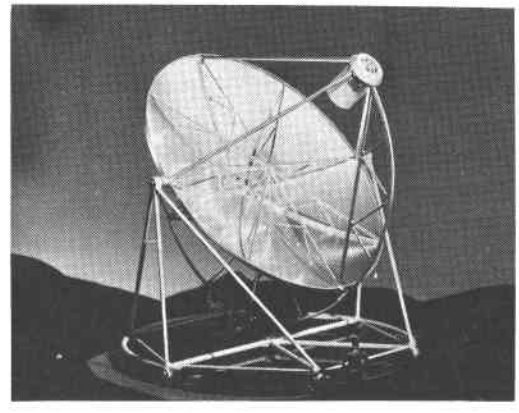
The Shenandoah Experiment Site

SECOND GENERATION AND ADVANCED PARABOLIC DISH DESIGNS

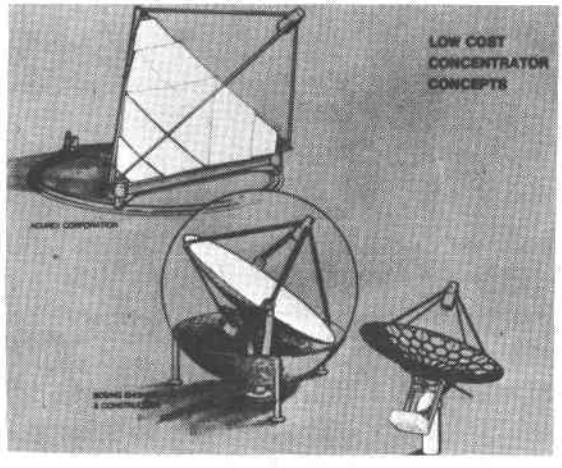
Parabolic dish concentrator costs must be reduced from current levels for point-focusing solar thermal systems to become commercially competitive. To meet this challenge, mass-producible designs offering low cost, high performance, reliability, and low maintenance are under development.

Second-generation components are presently in the fabrication phase. Candidate prototype concentrators and component hardware will soon be ready for performance testing and evaluation.

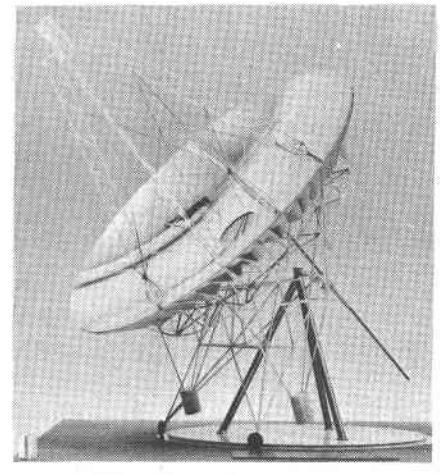
More advanced third-generation designs, which emphasize low-cost materials and manufacturing techniques, have undergone parameter optimization. These proposed low-cost concentrator concepts will be evaluated further, and one will be selected in fiscal year 1980 for final design, fabrication, and testing at the Parabolic Dish Test Site.



The General Electric Dish Design
Low-Cost Concentrator Concept



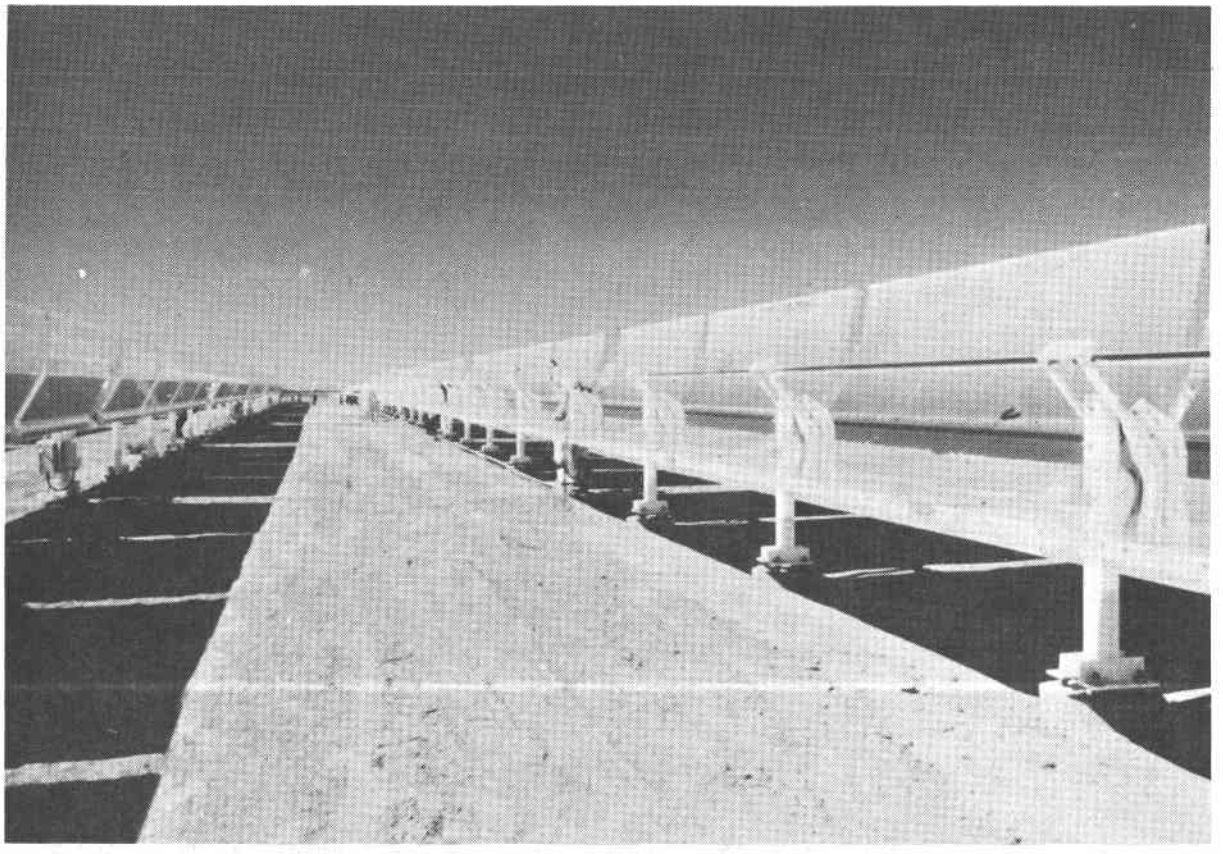
Low-Cost Concentrator Concepts



The Jet Propulsion Laboratory
Advanced Dish Design

LINE-FOCUSING DISTRIBUTED RECEIVER PARABOLIC TROUGH CONCENTRATORS

Line-focusing, distributed receiver parabolic trough concentrators have the ability to collect energy at greater than 60 percent efficiency at temperatures up to 600 °F. Recent studies show that they can economically compete with flat-plate collectors in most sections of the country, even at temperatures as low as 170 °F. The major long-range potential for parabolic troughs is in industrial total energy applications. For the near term, line-focusing collector systems may be used for displacing oil and natural gas in mid-temperature industrial heat and irrigation applications. Line-focusing systems also show potential for enhanced oil recovery applications, as an early opportunity market.



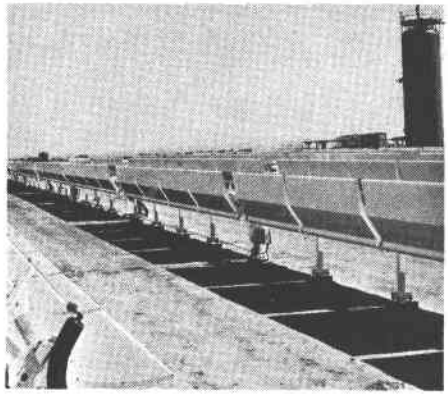
A parabolic trough concentrator focuses sunlight so that the heat can be collected by a mounted linear receiver.

PARABOLIC TROUGH SYSTEMS

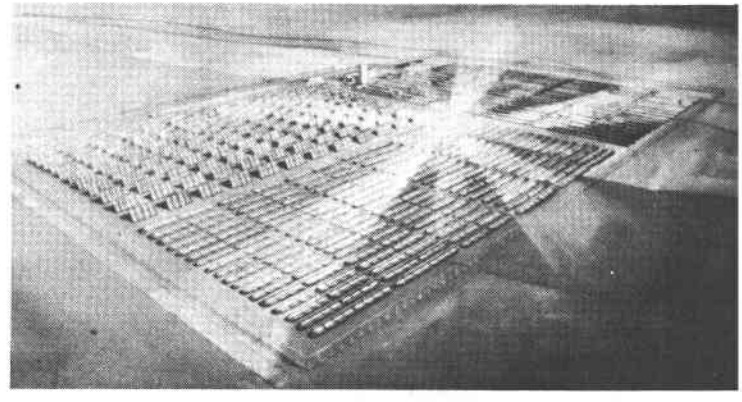
There are several major parabolic trough collector projects currently under design, construction, or operation both in the U.S. and abroad. These include:

- irrigation projects such as the 150-kWe Coolidge, Arizona, deep well irrigation experiment (operational);
- power generation projects such as the 500-kWe International Energy Agency (IEA) experiment in Almeria, Spain (under construction);
- total energy system designs such as that completed for a portion of the barracks complex at Fort Hood, Texas; and
- industrial process heat applications projects and demonstrations.

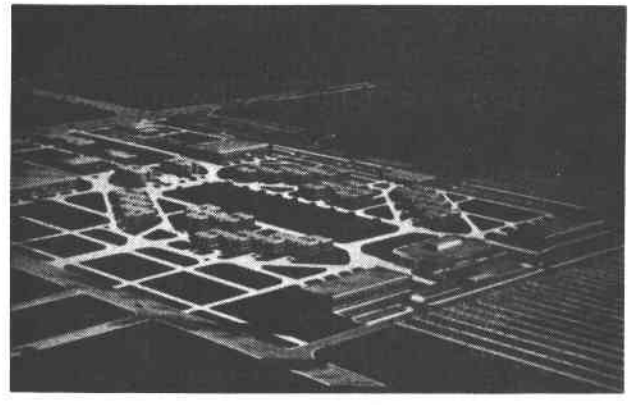
Coolidge Deep Well
Irrigation Experiment



The IEA Distributed Receiver
Power Generation Experiment



Fort Hood, Texas
otal Energy Experiment



Current and Proposed Parabolic Trough Projects

COOLIDGE IRRIGATION EXPERIMENT

Parabolic trough systems are being developed for application to critical irrigation needs in the Southwest. In this region, encompassing the state of California, Arizona, New Mexico, and Texas, over 160,000 irrigation wells are powered with natural gas. Solar-powered irrigation in the Southwest is on the way to becoming a sound alternative, both technically and economically, to gas which is subject to inevitable rate increases and uncertain supply.

The latest of these parabolic trough irrigation experiments is a DOE/State of Arizona joint project in Coolidge, Arizona. Recently dedicated, this project consists of a solar collector field, an energy storage (fluid tank), a heat engine, an irrigation pump, and controls. The sun-tracking collectors raise the temperature of the working fluid to approximately 500 ^{o}F. The heat engine, an organic Rankine-cycle turbine, runs on this hot fluid to power electric deep-well irrigation pumps. When not powering the irrigation pumps, the system can generate up to 150 kW of electrical power for other uses.

The 150-kWe Coolidge Irrigation Experiment

DISTRIBUTED RECEIVER TEST FACILITIES

The Mid-Temperature Solar Systems Test Facility (MSSTF) in Albuquerque, New Mexico, administrated by Sandia Laboratories, Albuquerque, serves as a national engineering evaluation center for mid-temperature components, subsystems, and system modules for DOE's Distributed Receiver Program. This facility has been in operation for three years and was the world's first application of the solar total energy concept.

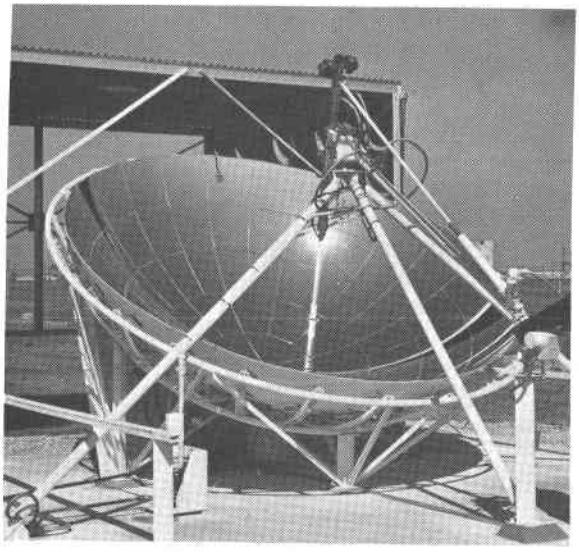
In the past, MSSTF testing capability has also been used for research and development (R&D) and operation and maintenance (O&M) data collection on numerous subsystems and systems, and for characterization of more than 12 commercially manufactured collectors. Subsystem development activities have included investigations of absorber coatings, low-cost mass-producible concentrator designs, and durability testing of trough modules.

The Collector Module Test Facility (CMTF) is part of the MSSTF. The CMTF has three test loops for testing collector modules at temperatures up to 800 ^{o}F and pressures up to 2,650 psi. Three mass-producible concentrator/substrate concepts are under investigation: sheet metal, sheet molding compound (SMC), and sandwich structure designs. In addition to collector testing, the facility is also available for operator training.

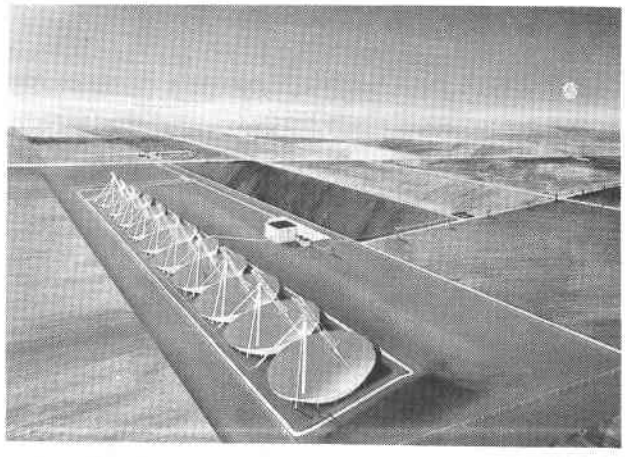
The Mid-temperature Solar Systems Test Facility

HEMISPHERICAL BOWL DEVELOPMENT

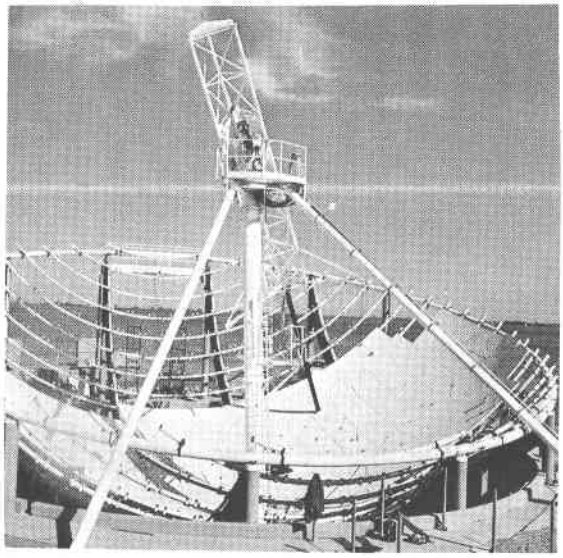
Hemispherical bowls are fixed mirror, moving receiver systems. Since the reflector is stationary, these systems are structurally simpler and can be built in larger modules than parabolic dishes. Bowl development has proceeded from a 3-meter diameter bowl (in 1977) to a 20-meter (65 foot diameter) prototype module. Based on cost and performance of these module experiments, a decision to proceed with a larger experiment will be made later in 1980.



1977: 3-Meter Diameter Bowl



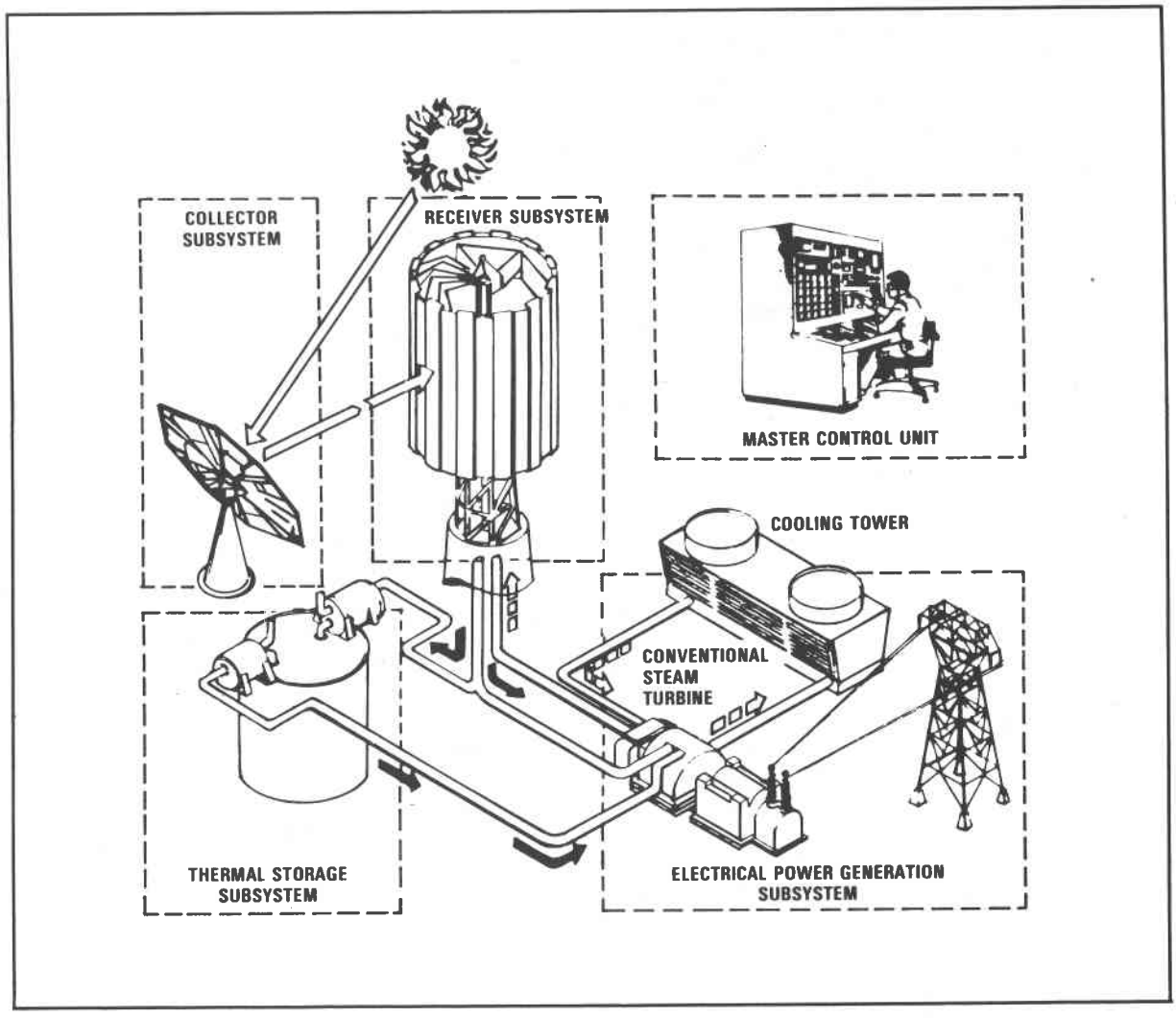
Proposed: 5-MWe Experiment
for the Town of Crosbyton, Texas



1979: 20-Meter Prototype Module

CENTRAL RECEIVER SYSTEMS

This collector concept consists of a field of sun-tracking mirrors, or heliostats, which redirect the sun's radiant energy onto or into a receiver mounted atop a centrally located tower. The heat so deposited is transferred to a working fluid circulating through the receiver and is used directly as process heat or to produce steam or hot gas for powering a turbine. In most instances, the working fluid used will be either water or gas. Water-based systems are generally intended for applications requiring temperatures only up to 1,000 ^{o}F, while systems using gas are capable of producing temperatures in the 1,000 ^{o}F to 2,000 ^{o}F range. Alternate concepts using molten salts and liquid metals as working fluids are also under investigation.

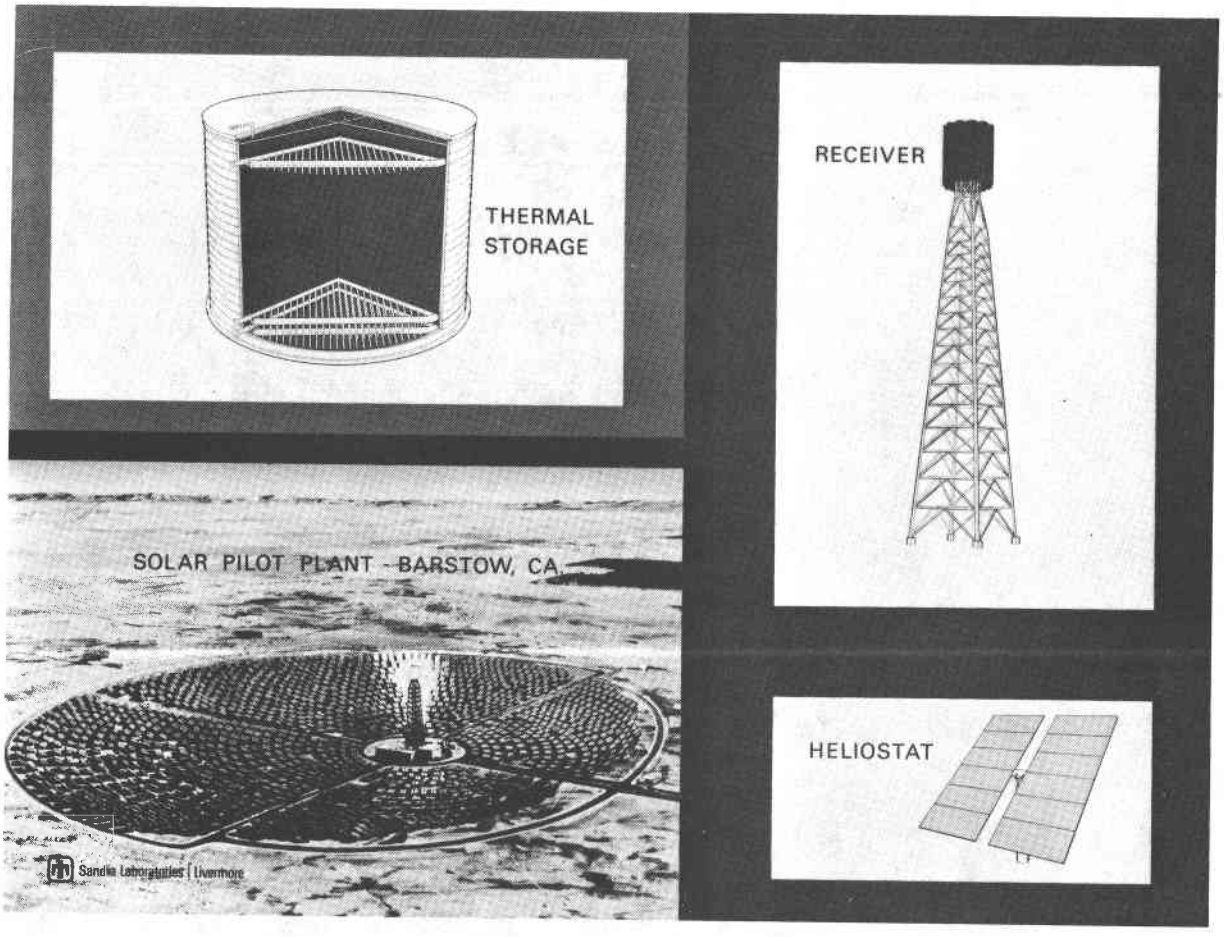


A Central Receiver System

THE 10-MWe BARSTOW PILOT PLANT

Currently, the Department of Energy is working with the Southern California Edison Company, the Los Angeles Department of Water and Power, the State of California and several private contractors to construct a 10-Megawatt-electric (MWe) central receiver pilot plant that will convert solar thermal energy into electrical energy, in an actual utility operating environment.

This pilot plant, currently under construction at Barstow, California, is scheduled to begin operations in late 1981 and will provide valuable development, production, operating, and cost data for commercial power plants of similar design.

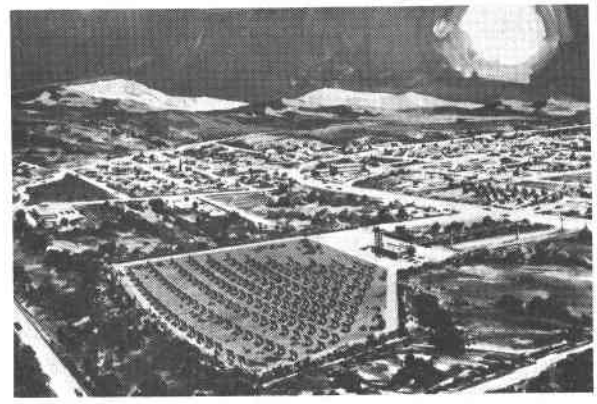


The Barstow Pilot Plant and Its Major Components

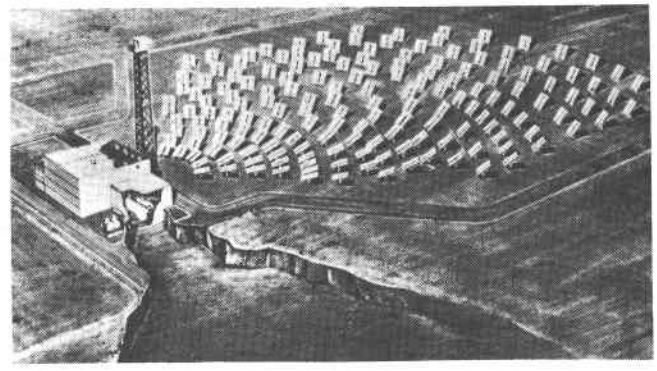
SMALL CENTRAL RECEIVER PROJECTS

In some small central receiver applications, two or more types of energy (for example, process heat and electricity) are produced. This is known as "cogeneration"; it holds great potential due to lowered capital cost per energy unit consumed through more complete utilization of solar energy collected. One possible near-term demonstration may involve an industrial application. Conceptual designs for such a project are to be solicited in FY 1980.

In another central receiver project, two 500-kWe solar electric generating plants will soon be constructed side by side in Almeria, Spain. One of these plants will employ a small central receiver design which incorporates a sodium-cooled, cavity-type receiver, while the other will utilize an array of distributed receiver, parabolic trough concentrating collectors. Electricity from both plants will be fed to consumers through the local utility grid system. This project is under the auspices of the International Energy Agency (IEA), an association of ten countries established to promote international cooperation in the research and development of energy systems.



A Cogeneration Application

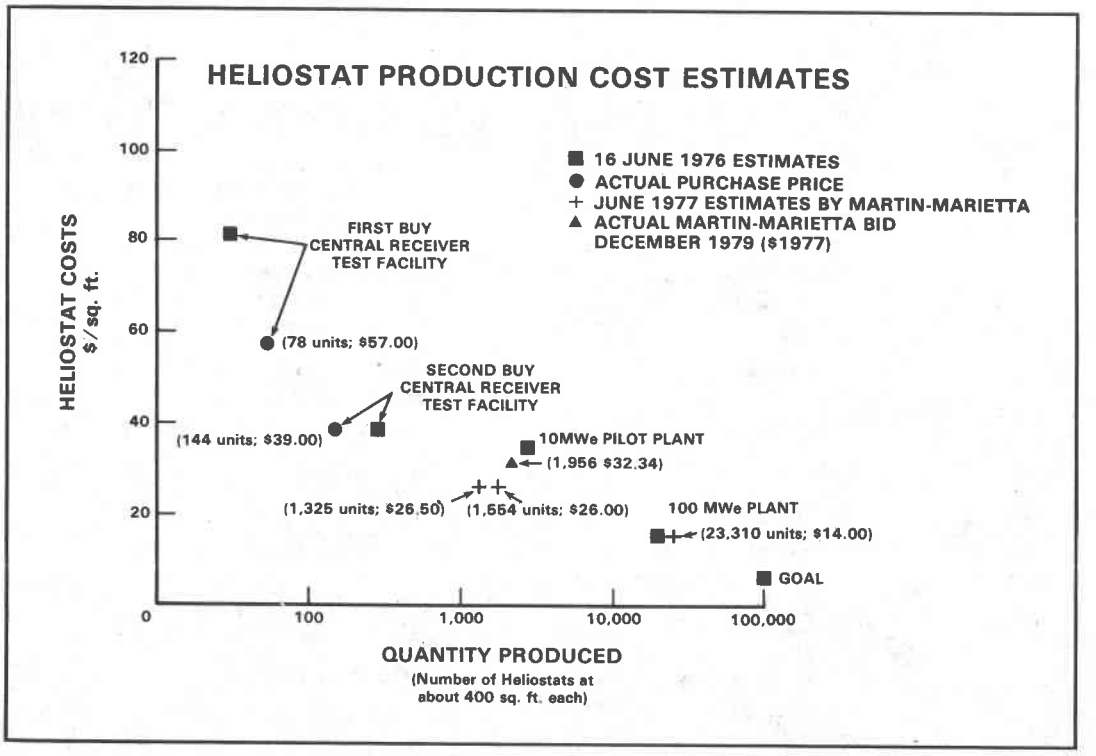


The IEA's Almeria, Spain
Small Central Receiver Design

HELIOSTATS

The heliostat collector field constitutes the largest fraction of the costs for both large and small central receiver systems. For this reason, heliostat development activities are keyed to achieving specific cost goals set for the near- and far-term, as well as meeting the technical requirements of promising central receiver applications. Projected heliostat costs for the Barstow pilot plant are only three times the program's 1990 cost goal of $\$9/ft^2$; this cost will decrease as knowledge of and experience with manufacturing techniques are acquired and as heliostat production grows.

Heliostat development effort is being conducted through competitive solicitations from private industry, with management and technical support provided by Sandia Laboratories in Livermore, California. The Heliostat Development Facility at Sandia includes a test bed for heliostat components and for development of improved instrumentation for hardware evaluation. Heliostat performance and operation are also tested at the Central Receiver Test Facility in Albuquerque, New Mexico.

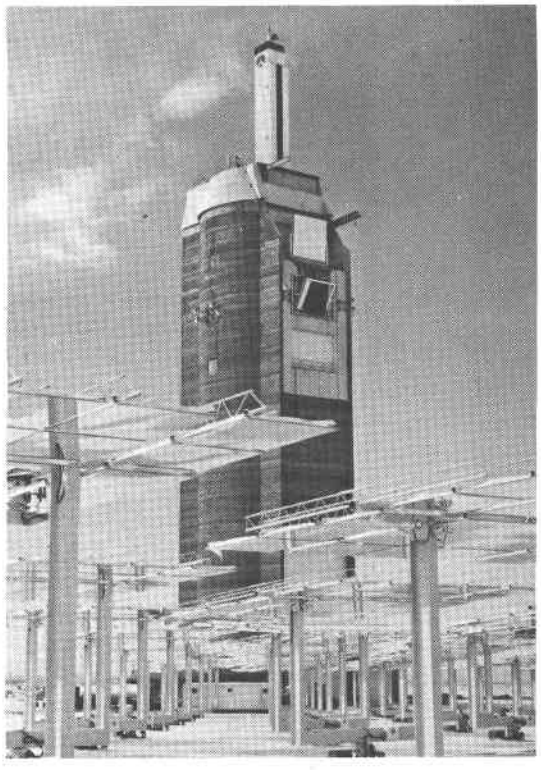


Heliostat Costs

POINT-FOCUSING RECEIVER SUBSYSTEMS

Besides the heliostat field, the receiver represents the most unconventional component of the central receiver concept. As part of the Solar Thermal Program, considerable effort is being channeled into the development of alternative receivers based on different heat transfer fluids. These fluids include water/steam, molten salt, liquid metals (such as sodium) and gases (such as air or helium). Each of these receiver concepts possesses different advantages for different applications.

Development work with receivers involves extensive testing at Sandia's Central Receiver Test Facility (CRTF) in Albuquerque. This facility's 222 heliostats can deliver in excess of 5-Megawatts-thermal (MWth) to various targets mounted atop a 200 ft. central tower and can theoretically produce temperatures greater than 4000 ^{o}F. This facility is intended to provide flexibility in testing new heliostat/receiver combinations, as well as to investigate advanced applications for central receiver technology and to acquaint technicians with solar facility operations.



The Central Receiver Test Facility

DOE CENTRAL RECEIVER PROGRAM

RECEIVER TESTING:
- DOE/MCDONNELL-DOUGLAS RECEIVER
- EPRI B/V RECEIVER
- DOE ADVANCED RECEIVERS
  - — MARTIN-MARIETTA MOLTEN SALT
  - — GE LIQUID SODIUM
- Ga/As PV ARRAY

HELIOSTAT TESTING:
- MCDONNELL-DOUGLAS BARSTOW DESIGN
- MARTIN-MARIETTA BARSTOW DESIGN

FACILITY TESTING:
- 5 MW FIELD
  - — ALIGNMENT AND BIAS
  - — REFLECTIVITY

OTHER PROGRAMS

SOLAR:
- 3-D CONCENTRATOR

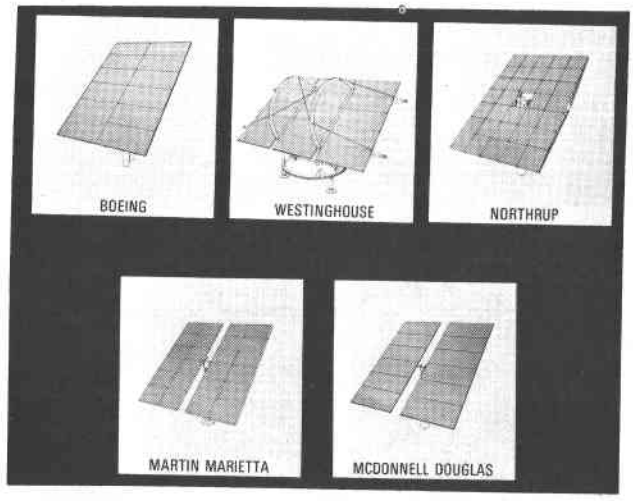
NON-SOLAR:
- APL RADOME
- SAI SOILS

CRTF Testing Activities Scheduled for FY 80

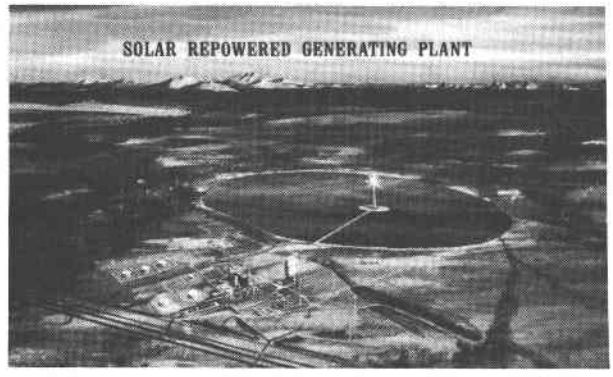
REPOWERING: A CENTRAL RECEIVER APPLICATION

Repowering refers to the installation of a solar steam generating system in parallel with an existing oil- or gas-fired boiler at an intermediate or peaking electric utility plant or for industrial applications. The solar system is used to displace fossil fuel, whereas the fossil boiler provides backup and maintains generating capacity when there is no solar resource. As a market of early opportunity (1985-1995), the potential exists for displacing 0.4 quads of thermal energy per year through utility repowering alone. Repowering, in addition to serving an immediate national need by displacing oil and natural gas, will provide utilities and industry with hands-on experience with solar thermal hardware and technology. It is also responsive to the Powerplant and Industrial Fuel Use Act of 1978 (part of the National Energy Act of 1978), which requires replacement of existing oil- and natural gas-fired units over 100 MBtu/hr in utility and, in some cases, industrial applications.

Repowering projects will create a market for large numbers of heliostats. To meet this expected demand, several companies are developing second generation heliostats which will feature improved performance and lower costs over present heliostat designs.



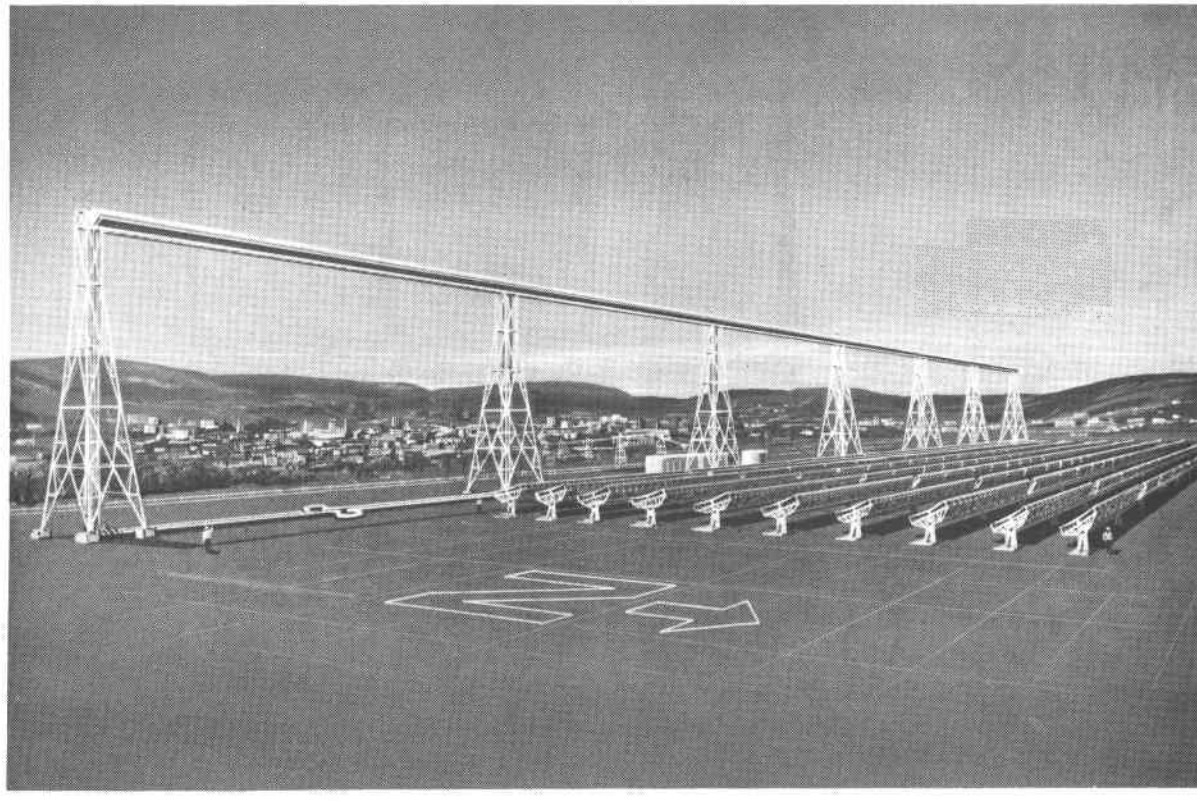
Second Generation Heliostats



A Solar Repowered Generating Plant

LINE-FOCUSING CENTRAL RECEIVER SYSTEMS

A line-focusing central receiver power system consists of a long, elevated horizontal receiver used in conjunction with multiple rows of line-focusing heliostats located parallel to the receiver. The line-focusing central receiver concept offers several potential cost-reducing features. First, the heliostats normally have a single-axis drive mechanism. Second, since the receiver is distributed over the collector field, shading and blocking are minimized. Third, when compared to point-focusing central receiver field layouts, the heliostats of line-focusing systems have a higher reflective surface density because they offer a continuous surface in one direction.



A Line-Focus Central Receiver System

ADVANCED TECHNOLOGY PROGRAM

The Advanced Technology program element sponsors research and development activities to provide improved, more economically attractive systems, subsystems, components, and materials in support of the overall Solar Thermal Program. Additionally, this element seeks to identify and provide seed funding for new and promising applications of solar thermal technology. Several key support efforts in the areas of environmental impacts, standards and reliability, insolation data resources, and technical information dissemination are also conducted as part of the Advanced Technology element.

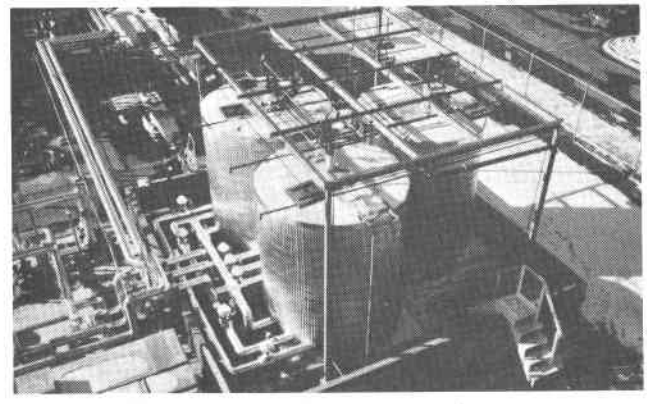
These primary functions are divided among the following program sub-elements:

- Materials
- Advanced Systems and Applications
- Advanced Subsystems and Components
- Supporting Programs

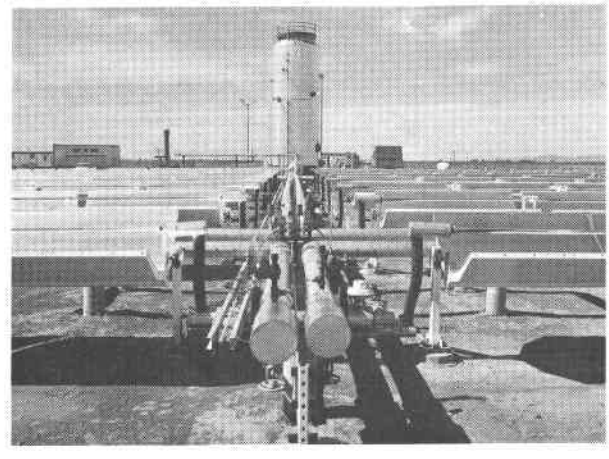
SOLAR THERMAL STORAGE SUBSYSTEMS

The development of thermal storage subsystems will have a significant leveraging effect in expanding the market potential for solar thermal systems. Without storage, all direct solar conversion systems are limited in their capacity factor to approximately 30 percent or less in most of the U. S. The ability to store high-temperature solar heat will be necessary to provide continuous system operation during periods of variable or unavailable sunlight (insolation), to buffer abrupt changes in insolation (due to intermittent cloud cover, for instance), and to ensure system capacity in emergency situations.

At the Coolidge, Arizona, irrigation experiment, a single-tank thermocline storage subsystem is being used. This design utilizes the naturally occurring temperature gradient in a tank of liquid to store heat. A multi-tank storage subsystem, on the other hand, uses two or more tanks to store the hot and cold fluids in the loop between the receiver and energy conversion system.



Liquid Transfer Multi-tank

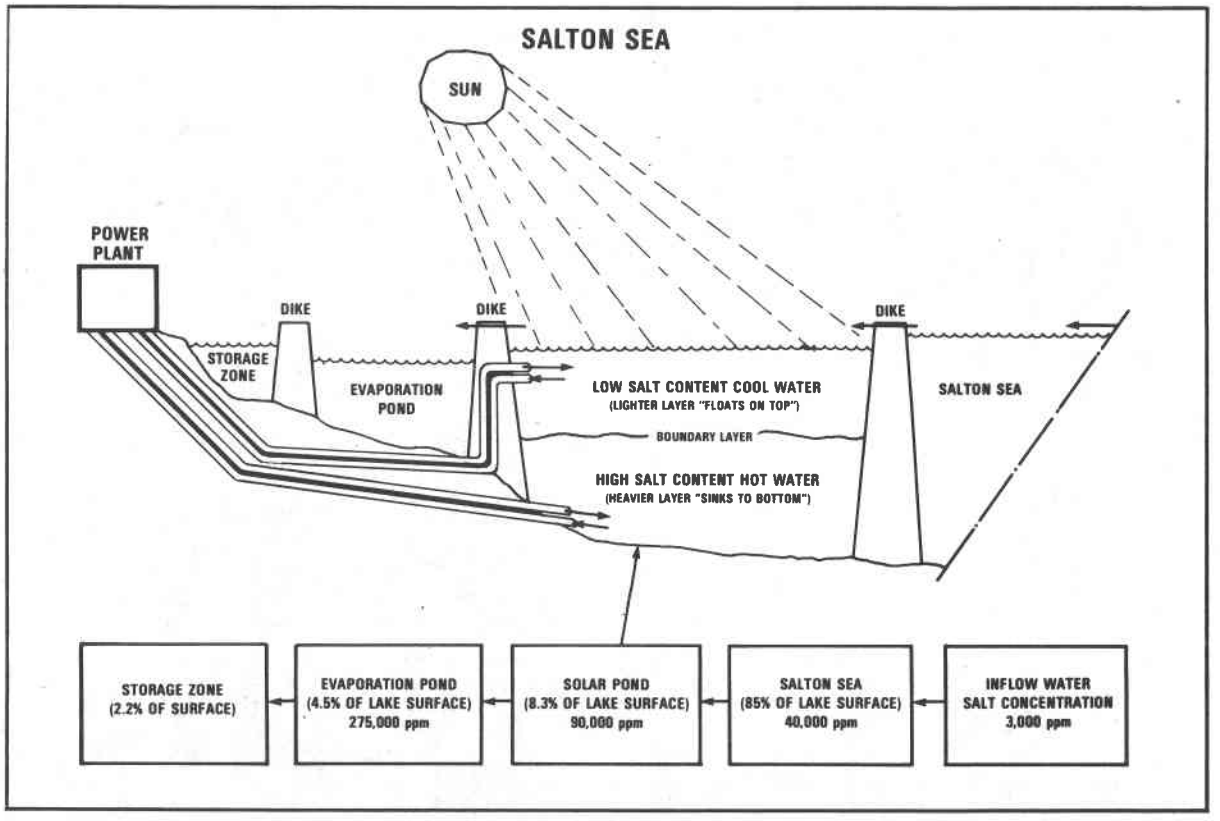


Thermocline Single-tank at the
Coolidge Irrigation Experiment

SOLAR SALT POND GENERATING PLANT

The solar pond represents one of the simplest solar energy collection devices, and its solar energy collection properties are a result of naturally occurring thermal processes. As incident radiation strikes the surface of the pond, a fraction of it travels to the floor of the pond where it is absorbed by the surrounding brine. Collected energy is stored in the brine until needed for use; at this point, the brine is drawn out of the bottom of the pond, piped to an energy conversion unit, and then returned to the surface of the pond.

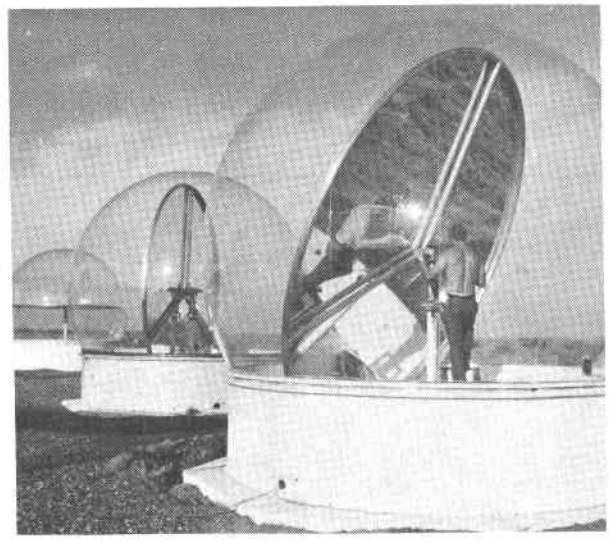
Present emphasis is on increasing the efficiency of this collection/storage process. The Department of Energy is engaged in a project with the Jet Propulsion Laboratory to determine the feasibility of salt ponds and to collect realistic cost data on them.



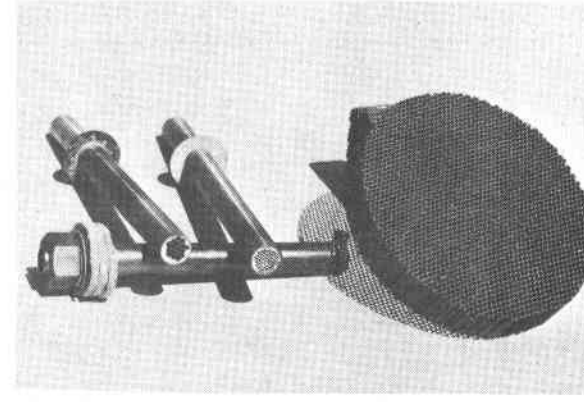
Solar Salt Pond Generating Concept

MATERIALS DEVELOPMENT

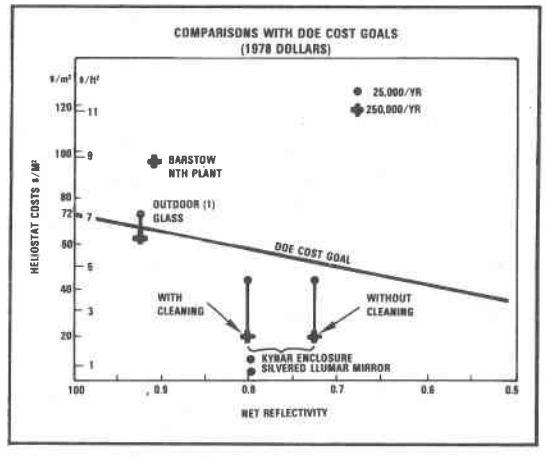
The materials portion of the Advanced Technology element is keyed to making cost-effective material options available to subsystem and system designers. The cornerstone of this activity is accurate characterization of existing engineering materials upon which advances in performance, durability, and cost can be based. Additionally, new materials are being identified and developed for instances where no suitable commercial substance exists. An example of this latter case is the need for a selective coating for absorbers capable of operating in the intermediate temperature range (750 ^{o}F to 1300 ^{o}F). Current and near-term efforts in the materials area include work with low-cost silver/glass mirror systems for reflectors; low-cost, stable plastics for transmitting materials; ceramics for high-temperature receivers; and structural support materials for advanced heliostats and concentrators.



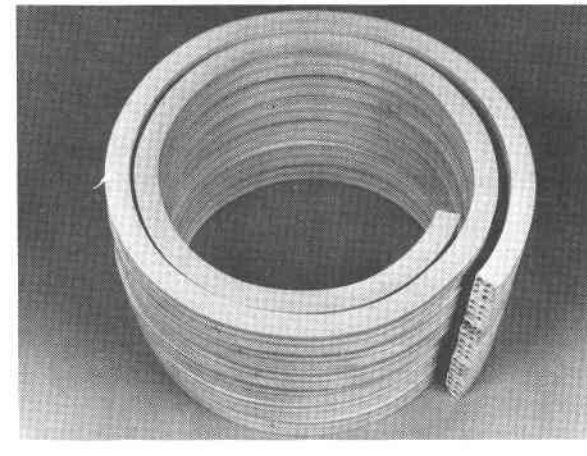
Boeing Bubble-Enclosed Heliostat



Cross-section of Honeycomb Heat Pipe a
Absorber Surface for use in a Heat Exchan



Heliostat Costs



High-Temperature Absorber Ceramic Material

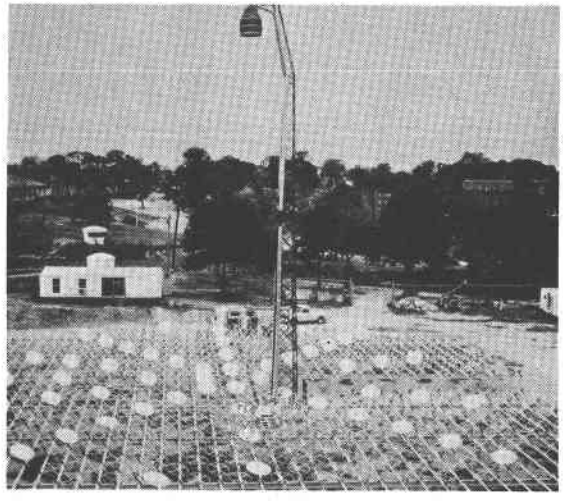
ADVANCED COMPONENTS AND SUBSYSTEM DESIGN

Research with advanced concepts and designs for subsystems and components will lead to improved performance and lower cost of later generation distributed and central receiver systems. Advanced technology work also emphasizes modular design approaches which can lead to highly adaptable concentrator systems.

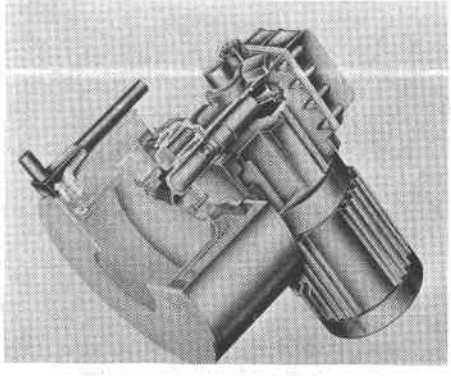
Testing and evaluation of advanced receiver components is underway at the Advanced Components Test Facility in Atlanta, Georgia. The Francia receiver, an Italian-designed high-pressure steam generator, has been tested at this facility at power levels up to 350 kWth. Advanced ceramic receivers for use with Brayton-cycle engines have also been tested and have produced temperatures up to 2,000 °F.

Technology for advanced Stirling-cycle engines is also being developed and tested. These engines are primarily intended for combination with dish concentrators to form high-efficiency modules for use in electric power generation applications. Currently, the Omnium-G parabolic dish collector module is the only commercially marketed parabolic dish system.

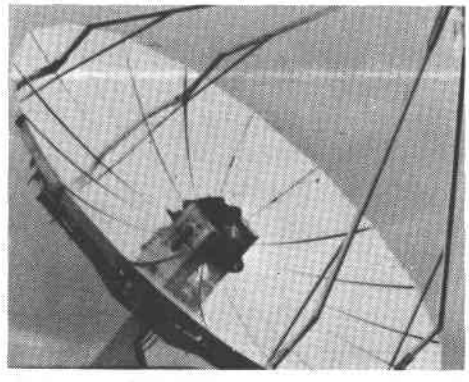
Advanced Components Test Facility



The Francia Receiver



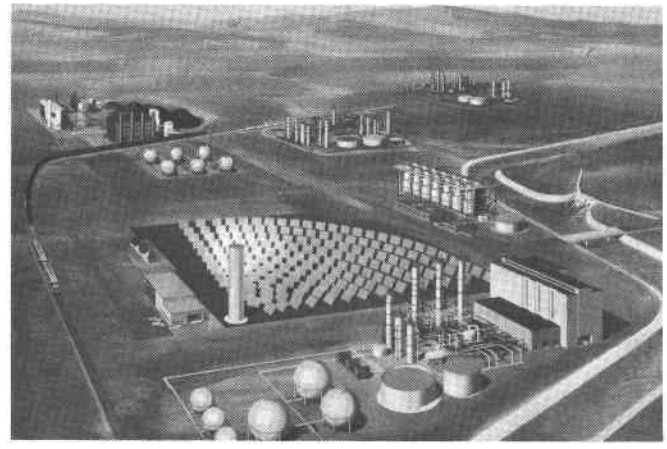
A Stirling Engine



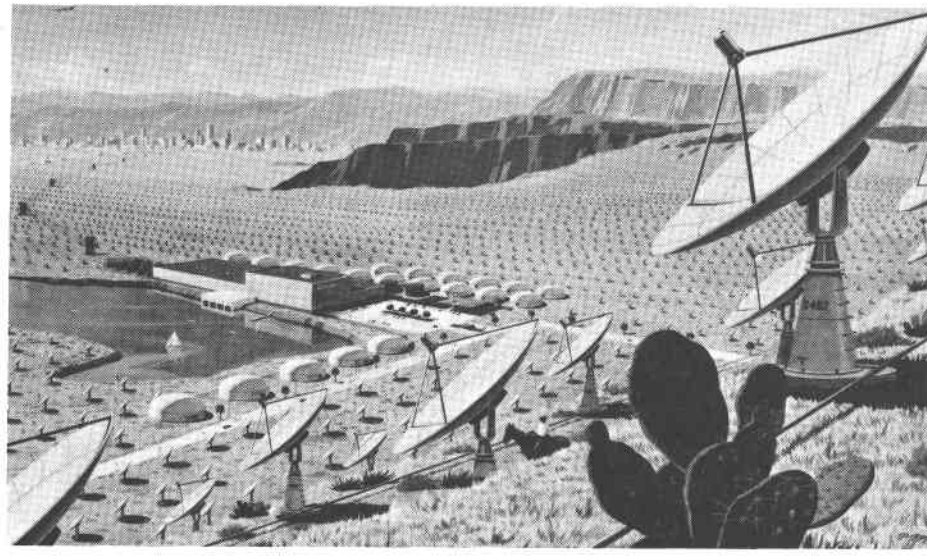
Omnium-G Dish

ADVANCED CONCEPTS

One of the efforts in the Advanced Technology area is to identify and develop new processes and applications for solar thermal energy. A major current thrust is the identification and development of fuels and chemicals production processes that would use solar energy as the heat source instead of conventional fossil fuels. Selection of an Industrial Project Manager for this element is expected to take place in FY 1980. Research is also being done on thermochemical heat transport processes using reversible thermochemical reactions. Such processes involve chemicals which undergo an energy-absorbing reaction in the receiver. The heat absorbed in the reaction can be released by reversing the reaction; thus, these chemicals can serve as both heat transport and storage systems.



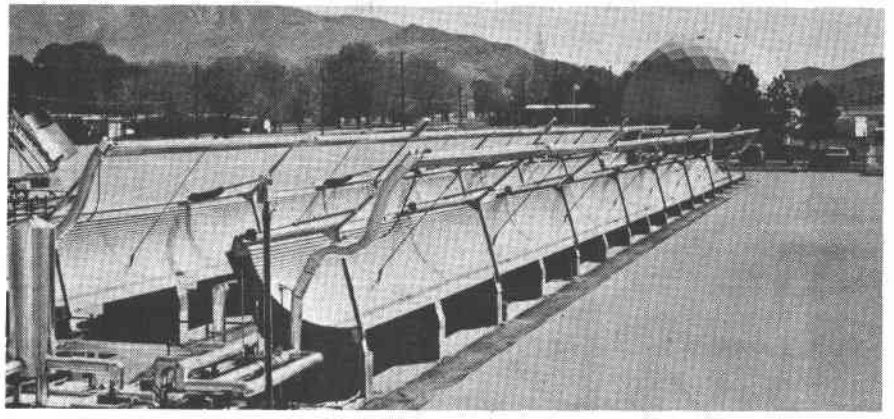
Fuels and Chemical Manufacture



Thermochemical Heat Transport

ENHANCED OIL RECOVERY

Besides supporting the development of new technology, the Solar Thermal Program is seeking out promising new applications for existing or near-term solar thermal systems. This category of new uses includes a group of processes known collectively as enhanced oil recovery techniques. Parabolic trough systems used as steam generators have been found to be especially suited to some of these techniques. In these applications, the trough collectors would be used to produce steam at temperatures up to 600 ^{o}F; the steam is then used to recover oil from marginally productive wells.



Production of steam for enhanced oil recovery is a potential early market for suppliers of trough collectors.

SUPPORTING PROGRAMS

The Supporting Programs effort within the Advanced Technology element addresses six areas of concern:

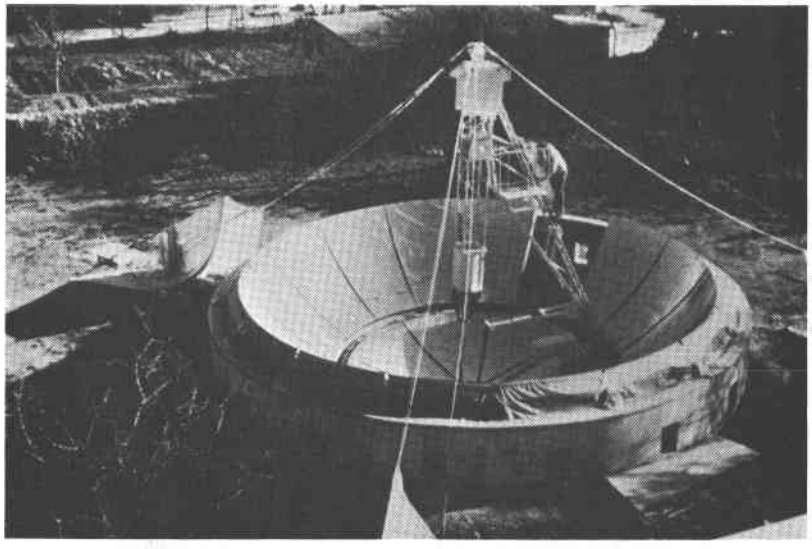
- Reliability and Standards
- Environmental Assessement
- Technology Information Dissemination
- University Support
- Test Facility Users Association
- Small/Minority Business Initiatives

INTERNATIONAL SOLAR THERMAL TECHNOLOGY

Interest in solar energy technology and its applications has not been unique to the United States. Many countries share the awareness that the sun will become an increasingly important energy resource as known world reserves of fossil fuels are drawn down.

One example of foreign activity with solar thermal technology is the French-designed Pericles concentrator. This unit is a hemispherical bowl lined with fixed mirror panels which redirect and concentrate sunlight onto a movable receiver. The mirror panels are formed of lightweight concrete with thin glass attached to the surface.

Research and development is also underway in other countries, including West Germany and Japan, as well as under the auspices of the International Energy Agency (IEA). One of the more visible international cooperative ventures is the IEA project at Almeria, Spain.



The Pericles Concentrator

FISCAL YEAR 1979

PROJECT SUMMARY TABLES

Table 1

A. Point-Focusing Systems Projects

(Distributed Receiver Systems)

Contractor/Subcontractor	Project ID No.	Title	Objective
Acurex Corporation, Alternate Energy Division	A-1	Low-Cost Point Focus Concentrator	To provide for the development up to the preliminary design of a point-focusing concentrator which has the potential in mass production of attaining a performance/cost of 0.004 to 0.12 kWth/$.
Arthur D. Little, Inc.	A-2	A Study of Mass Production and Industrialization of Small Solar Thermal Electric Power Systems	To investigate the means by which industry could produce and install point-focusing distributed receiver systems at minimum cost.
The BDM Corporation	A-3	A Workshop for Potential Users of Solar Thermal Electric Power Systems in Military and Related Civil Section Markets	To conduct a workshop for potential users of solar thermal electric power systems and define isolated applications and their respective markets.
Boeing Engineering & Construction Company	A-4	Low-Cost Point Focus Concentrator	To provide for the development up to the preliminary design of a point-focusing concentrator which has the potential in mass production of attaining a performance/cost of 0.004 to 0.12 kWth/$.
E-Systems, Inc./ Electrospace Systems, Inc.; ALCO Machine Co.	A-5	Test-Bed Concentrator	To assist in the development of point-focusing concentrators and testing at the subsystem and module level.
The Garrett Corporation	A-6	Phase II of the Air Brayton Solar Receiver	To develop prototype solar receivers for use in open-cycle air Brayton systems.
The Garrett Corporation	A-7	Phase II of the Steam Rankine Solar Receiver	To develop prototype solar receivers for use in steam Rankine systems.

Table 1 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
General Electric Company	A-8	The Effect of System Factors on the Economics of and the Demand for Small Solar Thermal Power Systems	To estimate the rate of market penetration for solar thermal technology in selected market sectors and develop cost-effective strategies for accelerating the rate of market penetration.
General Electric Company, Space Division	A-9	Low-Cost Point-Focus Concentrator	To provide for the development up to the preliminary design of a point-focusing concentrator which has the potential in mass production of attaining a performance/cost of 0.004 to 0.12 kWth/$.
General Electric Company, Space Division	A-10	Low-Cost Point-Focus Solar Concentrator, Phase II/III	To provide for the detailed design, fabrication, and installation of three units at the Parabolic Dish Test Site.
General Electric Company/ Lockwood-Greene, Architects & Engineers	A-11	Solar Total Energy Project Design for Shenandoah, Georgia Site	To develop solar total energy design experience and reduce risks of future design efforts through acquired data.
Georgia Power Company/ Shenandoah Development Inc.; Georgia Institute of Technology; Heery and Heery, Inc.; Owens-Corning Fiberglass; Westinghouse Electric Corp.	A-12	Solar Total Energy Project at Shenandoah, Georgia	To develop engineering experience for later commercial-size applications, reduce risk in future cost and performance predictions, and assess the interaction of technology in an industrial application with an electric utility system.
Pioneer Engineering and Manufacturing Company	A-13	Test-Bed Concentrator Cost Analysis	To obtain independent cost analysis of the Point-Focus Distributed Receiver Test-Bed Concentrator.

Table 1 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
Solar Energy Research Institute	A-14	Comparative Ranking of 0.1 to 10 MWe Small Solar Thermal Power Systems	To identify the most likely options for long-term commercialization of small solar thermal electric power systems through a comparative analysis of the major generic solar thermal electric systems.
Sun Power Corporation	A-15	Solar Concentrator Module Fold-up Unit: Design and Fabrication	To develop and demonstrate the technical feasibility of the fixed-mirror, distributed-focus solar energy concept.
Science Applications, Inc./ Black & Veatch, Consulting Engineers	A-16	Solar Thermal Plant Impact Analysis and Requirements Definition Study	To conduct impact analysis and requirements defintions of solar thermal electric power systems in utility and nonutility applications.

Table 2

B. Line-Focusing Systems Projects

(Distributed Receiver Systems)

Contractor/Subcontractor	Project ID No.	Title	Objective
Acurex Corporation	B-1	150 KWe Solar-Powered Deep-Well Irrigation Facility	To provide the design, construction, and operation of a solar-powered experimental facility to provide 150 KWe for the operation of deep-well irrigation pumps.
University of Arizona Optical Science Center	B-2	Study of Small Module Fixed-Mirror Distributed-Focus Photothermal Concentrators	To perform a comparative analysis of small module fixed-mirror distributed-focus concentrators with other existing fixed-mirror designs.
Oak Ridge National Laboratory, Union Carbide Corporation/ The Aerospace Corporation	B-3	Small Solar Power Systems Mission Analysis	To provide program planning and analytical support for implementation of the Small Thermal Power Systems Program Plan.
Sandia Laboratories	B-4	Midtemperature Component and Subsystem Development Project	To develop line-focus concentrating collector subsystems with high performance, durability, and reliability utilizing mass-production technology with potential for low cost.
Sandia Laboratories	B-5	Midtemperature Solar System Test Facility	To operate and maintain a test facility for concentrating solar collectors and identify design and system integration considerations.
Sandia Laboratories	B-6	Solar Energy Systems and Application Development	To promote the use of solar power in on-site applications through experiments performed in conjunction with the private sector.

Table 2 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
Sandia Laboratories	B-7	Solar Irrigation Facility Operation	To provide for the operation, maintenance, testing, and performance cost analyses relating to operating solar irrigation projects at Willard, New Mexico; Gila Bend, Arizona; and Coolidge, Arizona.
Texas Tech University/ E-Systems, Inc.; Foster Wheeler Development Corp.	B-8	Crosbyton Solar Power Project	To develop and demonstrate the technical feasibility fo the fixed-mirror, distributed-focus solar energy concept.

Table 3

C. Systems and Applications Projects

(Central Receiver Systems)

Contractor/Subcontractor	Project ID No.	Title	Objective
Aerospace Corporation	C-1	Systems Engineering Studies and Program Technical Support	To assist DOE-SAN in the management of industry contracts in the field of developing large power systems for deriving electrical power from solar energy.
Arizona Public Service Co./ Martin Marietta Aerospace Corp.; Badger Energy, Inc.; Gibbs-Hill, Inc.	C-2	Solar Repowering/Industrial Retrofit systems	To provide a site-specific conceptual design for solar repowering.
BDM Corporation/ Stearns-Roger Engineering Co.; Public Service of New Mexico	C-3	Line Focus Solar Thermal Central Power	To develop a conceptual design of a 100-MWe power plant which utilizes a solar parabolic trough collecting system.
Bechtel National, Inc./ Dynatherm Corp.; Foster Wheeler Development Corp.	C-4	Preliminary Heat Pipe Testing Program	To obtain life and performance data on a heat pipe in an experiment simulating that proposed for a Brayton-cycle solar receiver.
Bechtel National, Inc./ Foster Wheeler Development Corp.; Northrup, Inc.; Public Service of New Mexico	C-5	Solar Central Receiver Hybrid Power System	To select, develop, and assess concepts for electrical generating plants combining solar thermal central receiver and conventional fossil-fired thermal energy sources.
Black & Veatch Consulting Engineers/Babcock & Wilcox Co.; Public Service Co. of Oklahoma	C-6	Solar Repowering for Electrical Generation	To provide a site-specific conceptual design for solar repowering.

Table 3 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
Boeing Engineering & Construction Company	C-7	Central Receiver Solar Thermal Power System	To design and develop a collector subsystem which can be integrated with other subsystems to demonstrate the technical feasibility and potential economic feasibility of solar thermal water/steam central receiver-type power plants.
Boeing Engineering & Construction Company/Brown-Boveri & Company; Stone & Webster; United Technology Research Center	C-8	Conceptual Design of Advanced Central Receiver Power Systems, Phase I	To evaluate candidate designs for an advanced technology terrestrial solar-electric generating system.
Boeing Engineering and Construction Company/ U. S. Gypsum Company; Institute of Gas Technology	C-9	Solar Repowering/Industrial Retrofit Systems	To provide a site-specific conceptual design for solar retrofit.
El Paso Electric Co./ Stone & Webster	C-10	An Industry Survey of the Potential for Solar Feedwater Heating	To evaluate existing economic and fuel savings analyses for solar feedwater heating based on the contractor's analyses of El Paso Electric's fossil-fueled electric power plants.
El Paso Electric Co./ Westinghouse Electric Corp.; Stone & Webster	C-11	Solar Repowering/Industrial Retrofit Systems	To provide a site-specific conceptual design for solar repowering.
Energy Foundation of Texas/ University of Houston	C-12	Solar Energy System Simulation and Analysis	To develop appropriate user guides for a previously developed array of central receiver optical performance, simulation, and optimization codes.

Table 3 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
FMC Corporation, Engineering Systems Division	C-13	Line Focus Solar Thermal Central Receiver Research Study	To develop and assess the performance of a specific design of a line-focus type of system.
Foster Wheeler Development Corporation/McDonnell Douglas Astronautics Company; Provident Energy Company	C-14	Solar Repowering/Industrial Retrofit Systems	To provide a site-specific conceptual design for solar retrofit.
General Atomic Company/ Bechtel National, Inc.; Rockwell International Corp.	C-15	Line Focus Solar Central Power Systems, Phase I (Conceptual Design)	To develop a conceptual design of a stand-alone Line Focus Solar Central Power System.
General Electric Company/ Energy Foundation of Texas; Foster Wheeler Development Corporation; Kaiser Engineers, Inc.	C-16	Conceptual Design of Advanced Central Receiver Power Systems, Phase I	To establish the feasibility of developing a central receiver system that will significantly reduce the cost of electricity generated from solar central receivers.
General Electric Company/ Foster Wheeler Development Corporation; Kaiser Engineers, Inc.	C-17	Alternative Central Receiver Power System, Phase II	To refine the conceptual design of the commercial plant as described in Phase I.
General Electric Company/ Southwestern Public Service Co.; Kaiser Engineers, Inc.	C-18	Southwestern Public Service Company Solar Repowering	To provide a site-specific conceptual design for solar repowering.
Martin Marietta Aerospace Corp., Denver Division/ Arizona Public Service Co.; Badger Plants, Inc.; Black & Veatch Consulting Engineers	C-19	Conceptual Design of Advanced Central Receiver Power Systems, Phase I	To conduct systems analysis and develop conceptual designs for advanced central receiver power systems.

Table 3 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
Martin Marietta Aerospace Corp., Denver Division/ Arizona Public Service Co.; Badner Energy, Inc.	C-20	Alternative Central Receiver Power System, Phase II	To refine the conceptual design of the commercial plant as described in Phase I.
Martin Marietta Aerospace Corp., Denver Division/ Department of Civil Engineering Colorado State University	C-21	Central Receiver Solar Thermal Power System Heliostat Field Wind-Effects Test	To determine the effects of wind on a heliostat field with and without fences around the perimeter.
Martin Marietta Aerospace Corp., Denver Division/ Foster Wheeler Development Corporation	C-22	Central Receiver Solar Thermal Power System: Testing of Subsystem Research Experimental Receiver at CRTF, Phase II	To obtain performance data on the 5-MWt recirculation flow cavity receiver in the solar environment at the CRTF.
Martin Marietta Aerospace Corp., Denver Division/ Arizona Public Service Co.; Badger Plants, Inc.; Foster Wheeler Development Corp.; Gibbs & Hill, Inc.	C-23	Solar Central Receiver Hybrid Power System	To select, develop, and assess concepts for electrical generating plants combining solar thermal central receiver and conventional fossil-fired thermal energy sources.
Martin Marietta Aerospace Corp., Denver Division/ Exxon Corporation; Foster Wheeler Development Corp; Black & Veatch Consulting Engineers	C-24	Solar Repowering/Industrial Retrofit Systems	To provide a site-specific conceptual design for solar retrofit.

Table 3 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
McDonnell Douglas Astronautics Company/ Rockwell International	C-25	Central Receiver Solar Thermal Power Systems: Modification of Receiver Subsystem Research Experiment for Testing at CRTF	To obtain comprehensive data on performance, response to transient conditions, and operational procedures for a representative single panel of the Barstow 10-MWe pilot plant external receivers.
McDonnell Douglas Astronautics Company/ Gulf Research and Development Company; University of Houston; Foster Wheeler Development Corp.	C-26	Gulf Mt. Taylor Uranium Mill Solar Retrofit	To provide a site-specific conceptual design for solar retrofit.
McDonnell Douglas Astronautics Company/ University of Houston; Foster Wheeler Development Corp.; Westinghouse; Stearns-Roger Engineering Co.; Desert Research Institute; Sierra Pacific Power Company	C-27	Solar Repowering/Industrial Retrofit Systems	To provide a site-specific conceptual design for solar repowering.
Northrup, Inc./ Arco Oil & Gas Company	C-28	Solar Industrial Retrofit Systems	To provide a site-specific conceptual design for solar retrofit.
PFR Engineering Systems, Inc./ Valley Nitrogen Producers, Inc.; McDonnell Douglas Astronautics Company	C-29	Valley Nitrogen Producers Ammonia Plant Solar Retrofit	To provide a site-specific conceptual design for solar retrofit.

Table 3 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
Rockwell International Corp., Energy Systems Group/ McDonnell Douglas Astronautics Company; Stearns-Roger Engineering Company; University of Houston; Salt River Project	C-30	Conceptual Design of Advanced Central Receiver Power Systems	To select and develop a conceptual design for an advanced central receiver power system.
Rockwell International Corp., Energy Systems Group/ Babcock & Wilcox; McDonnell Douglas Astronautics Co.; Salt River Project; SRI International; Stearns-Roger Engineering Company; University of Houston	C-31	Solar Central Receiver Hybrid Power Systems	To select, develop, and assess concepts for electrical generating plants combining solar thermal central receiver and conventional fossil-fueled thermal energy sources.
Rockwell International Corp., Energy Systems Group/ Texas Electric Service Co.; McDonnell Douglas Astronautics Company; Stearns-Roger Engineering Co.; University of Houston	C-32	Texas Electric Service Company Solar Repowering	To provide a site-specific conceptual design for solar repowering.
SRI International	C-33	Analysis of Mesoscale Weather and Climate Changes Caused by Large Solar Electric Power Plants and Their Effects on Plant Performance	To determine any significant atmospheric effects of large solar thermal power plants on local and regional weather.

Table 3 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
SRI International/Bechtel National, Inc.; Foster Wheeler Development Corp.; Pacific Gas & Electric Co.; Acurex	C-34	Line Focus Solar Central Power Systems, Phase I (Conceptual Design)	To prepare a conceptual design of a 100-MWe power plant which utilizes tower-mounted, linear cavity heat receivers.
U. S. Bureau of Reclamation/ USBR Engineering & Research Center	C-35	Solar Thermal Electric Plants in a Hydroelectric Grid	To evaluate costs and benefits of integration of solar central receiver power plants into the Bureau of Reclamation hydroelectric grid.
Westinghouse Electric Corp.	C-36	Economic Assessment of Advanced Solar Thermal Plants	To evaluate the economic impact upon specific electric utility systems of a variety of concepts and configurations of solar thermal power plants in a role of central station electrical generating systems.

Table 4

D. Subsystems and Components Projects

(Central Receiver Systems)

Contractor/Subcontractor	Project ID No.	Title	Objective
Argonne National Laboratory	D-1	Materials Testing for Central Receiver Systems	To provide mechanical properties data on specific candidate materials for application in central receivers.
Babcock and Wilcox/ Black & Veatch Consulting Engineers	D-2	Receiver Design	To conceptually design an advanced water/steam receiver.
Battelle Pacific Northwest Laboratories	D-3	Development of Mirror Specifications	To develop specifications that will enhance the durability and life-time of heliostat mirrors.
Beckman Instruments, Inc.	D-4	Portable Absolute Reflectometer	To develop two portable handheld prototype absolute reflectometers to assess mirror reflectance or plastic film degradation as a consequence of weathering.
Boeing Engineering and Construction Company/ Pennwalt Corporation	D-5	One-Piece Dome Fabrication Study	To investigate thermoforming techniques that will allow the forming of a dome from a single piece of relatively thick material.
Boeing Engineering and Construction Company/ Desert Sunshine Exposure Test Facility	D-6	Plastic Film Performance Improvement	To develop and test improved enclosure and reflector plastic films.

Table 4 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
Boeing Engineering and Construction Company/ Ford Aerospace; Pittsburg-Corning	D-7	2nd Generation Heliostat Development	To provide a high-performance, low-life-cycle-cost heliostat design that can be volume produced at rates of 25,000 - 50,000 per year with an assumed 30-year plant lifetime.
Combustion Engineering, Inc.	D-8	Advanced Water/Steam Receiver Conceptual Design	To develop on a conceptual design basis a water/steam boiler which is more cost effective than those proposed for the pilot plant.
Combustion Engineering, Inc.	D-9	Receivers	To provide independent analysis of MDAC/CRTF and Sandia 5-Tube Test data for relevance to the Barstow pilot plant receiver design.
Energy Foundation of Texas/ Texas Tech University	D-10	Analysis of Extreme Winds on Solar Tower Generators	To experimentally determine the vortex shedding frequencies of a single heliostat.
Fluor Pioneer	D-11	Cost Analyst Services	To normalize solar central receivers contractor cost estimates to a common basis.
Foster-Miller Associates, Inc.	D-12	Automatic Heliostat Cleaning System	To provide an in-depth evaluation of the requirements for heliostat cleaning and optimal development of a system to meet these requirements.

Table 4 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
Foster Wheeler Development Corporation	D-13	Interim Structural Design Standard for Solar Energy Applications	To investigate the applicability of the present ASME Boiler Codes to solar energy systems, particularly receivers, and to develop an applicable interim structural design standard.
General Atomic Corporation	D-14	Corrosion Fatigue	To determine the susceptibility of 1,800 tube samples to combined corrosion fatigue in boiling water and superheated steam environments.
General Electric Company	D-15	Electric Power Generation System (EPGS) Study	To define possible unique combinations of receiver and thermal storage steam conditions which can be utilized by existing steam turbines in support of the Advanced Water/Steam Receiver Program.
General Electric Company	D-16	Heliostat Materials Development and Evaluation Program	To establish a firm data base for prediction of useful life cycles and performance of enclosed heliostat materials.
General Electric Company	D-17	Pilot Plant Receiver	To provide independent analysis of MDAC/CRTF and Sandia 5-Tube Test data for relevance to the Barstow pilot plant receiver design.
General Electric Company	D-18	Review IEA Project	To provide an independent assessment of the IEA sodium central receiver.

Table 4 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
General Electric Co., Energy Systems & Tech. Division	D-19	Design Feedwater System	To develop a feedwater system and a water chemistry monitor station for use in the 5-Tube Departure from Nucleate Boiling Test.
General Electric Company, Space Division	D-20	Molded Plastic Heliostat Reflective Panels	To develop a low-cost, high-strength, lightweight heliostat reflector panel based on moldable epoxy compounds.
Honeywell, Inc., Energy Resource Center	D-21	Honeywell Latent Heat Thermal Storage Subsystem Research Experiment	To collect a quantitative set of experimental data to evaluate a particular design concept for storage of thermal energy vs. heat of fusion in salts.
University of Illinois Dept. of Mechanical and Industrial Engineering	D-22	Experimental Study of Convective Losses from Solar Receivers	To support receiver design by establishing convective losses of both external and cavity receivers for various wind vectors.
Martin Marietta Aerospace Corporation	D-23	Advanced Water/Steam Receiver Design	To design a cost-effective water/steam receiver system.
Martin Marietta Aerospace Corporation	D-24	2nd General Heliostat Development for Solar Central Receiver	To provide a high-performance, low life-cycle cost heliostat design that can be volume produced at rates of 25,000-50,000 per year with an assumed 30-year plant life.
Martin Marietta Aerospace Corporation	D-25	Salt Experiment	To provide data on techniques for low-cost containment of molten salt storage media.

Table 4 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
Martin Marietta Aerospace Corporation	D-26	Storage Fluid Evaluation	To provide engineering and chemical data regarding the changes in hydrocarbon oil with exposure to high temperature.
McDonnell Douglas Astronautics Co.	D-27	2nd Generation Heliostat Development	To provide a high-performance, low life-cycle cost heliostat design that can be volume produced at rates of 25,000-50,000 per year with an assumed 30-year plant life.
McDonnell Douglas Astronautics Co.	D-28	Non-Inverting Heliostat Study	To investigate the implications of employing a non-inverting heliostat design where vertical stow is normally used and mirror-up stow is used to survive extreme winds.
McDonnell Douglas Astronautics Co.	D-29	Test Rocketdyne Receiver	To provide testing for the MDAC/CRTF receiver test.
Northrup, Inc./ Booz-Allen & Hamilton, Inc.; Bechtel National, Inc.	D-30	2nd Generation Heliostat Development	To design and develop a low-cost heliostat.
Progress Industries	D-31	Heliostat Drive and Protection System Components	To develop a cable drive system for a pedestal-type heliostat, and a protective cover and cleaning system for the reflective surface.
Schumacher & Associates, Inc.	D-32	New Ideas for Heliostat Reflector Cleaning Systems	To develop and evaluate methods for cleaning glass heliostat mirrors with the use of water.

Table 4 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
Solaramics, Inc.	D-33	Foamed Glass	To develop and demonstrate a foamed glass production process.
Solaramics, Inc.	D-34	Heliostat Drive Mechanism	To design and test a modified azimuth-evaluation heliostat drive mechanism.
Springborn Laboratories	D-35	Prevention of Soiling of Heliostat Surfaces	To develop treatments for the glass surface or plastic dome covering an alumunized Mylar mirror of a heliostat to prevent or minimize soiling, and to facilitate cleaning.
Stearns-Roger Engineering Co.	D-36	Receiver Tower Cost Study	To obtain tower cost data for use in current and future solar central receiver studies.
Sun Power Corporation	D-37	Feathering Heliostats and Drive Systems	To investigate alternative concepts for a heliostat drive mechanism.
Westinghouse Electric Corp., Advanced Energy Systems Division	D-38	2nd Generation Heliostat Development Program	To provide a high-performance, low life-cycle cost heliostat design that can be volume produced at a rate of 25,000-50,000 per year with an assumed 30-year plant lifetime.

Table 5

E. Materials Technology Projects

(Advanced Thermal Technology)

Contractor/Subcontractor	Project ID No.	Title	Objective
Solar Energy Research Institute	E-1	Supporting Materials Research for Solar Thermal Program	To define new or improved materials which can be made available to system designers through direct commercialization or process development.
Solar Energy Research Institute/ University of Arizona	E-2	Chemical Vapor Deposition of Refractory-Metal Reflectors for Spectrally Selective Solar Absorbers	To develop chemical vapor deposition technologies.
Solar Energy Research Institute/ Clarkson College of Technology	E-3	Oxidative Degradation of Polypropylene by Copper Oxides	To investigate the importance of copper ions at copper/polymer interface and evaluate means to inhibit this catalytic action.
Solar Energy Research Institute/ Cornell University	E-4	Optical Properties of Metallic Surfaces, Small Particles, and Composite Coatings	To develop a theoretical model explaining the interactions of metal particles with light.
Solar Energy Research Institute/ Corning Glass Works	E-5	Evaluation for Thin Glass	To evaluate the melting and forming characteristics of 780X glass and the limits of the fusion process for producing sheet glass to 0.25mm thick glass.
Solar Energy Research Institute/ Dow Corning Corporation	E-6	Development of Reflective Surface Protective Coatings	To develop protective coatings that will be inexpensive and durable, and cause attenuation of the reflected solar radiation.

Table 5 (continued)

Contractor/Subcontractor	Project ID No	Title	Objective
Solar Energy Research Institute/ Englehard Industries Division, Englehard Mineral and Chemical Company	E-7	Improved Absorbing Coatings for Thermal Utilization of Solar Energy	To develop selectively absorbing films prepared by the thermal decomposition of metallo-organic solutions for solar receivers at 300 ^{o}C to 700 ^{o}C.
Solar Energy Research Institute/ Exxon Research & Engineering Company	E-8	High-Temperature Solar Absorber Coatings	To develop low-cost, high-temperature receiver coatings that can be applied using conventional paint spraying techniques and are amenable to "in place" repair.
Solar Energy Research Institute/ Energy Foundation of Texas, University of Houston	E-9	Surface Morphologies of Efficient Solar Energy Absorbing Materials	To compare the optical properties of various laboratory and commercial metals and determine the role of surface morphology and microstructure in defining the optical absorption and emissions of absorber coatings.
Solar Energy Research Institute/ University of Minnesota	E-10	Composition Profiling of Solar Coating Materials	To provide analytical support for other absorber surface contractors.
Solar Energy Research Institute/ Jet Propulsion Laboratory	E-11	Technical Support of Cellular Glass Programs	To plan and coordinate a broadbased materials technology program and act as a lead center for planning and management of cellular glass technology.
Solar Energy Research Institute/ Telic Corporation	E-12	Evaluation of Vacuum Deposition as a Technique for Producing Solar Receiver Coatings	To ascertain the value of vacuum sputtering as a technique for depositing a Pt/Al_2O_3 cermet absorber coating and to determine the feasibility for the production of solar absorber coatings.

Table 5 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
Solaramics, Inc.	E-13	Cellular Glass Development	To supply state of the art cellular glass materials to JPL for property characterization.

Table 6

F. Advanced Subsystems Projects

(Advanced Thermal Technology)

Contractor/Subcontractor	Project ID No.	Title	Objective
Acurex Corporation	F-1	An Advanced Solar Concentrator Design	To obtain realistic fabrication costs required to mass produce an 11-meter diameter advanced solar concentrator.
General Electric Company, Space Division	F-2	Design, Fabrication, and Acceptance Test of a Heat Pipe Solar Receiver with Thermal Energy Storage	To develop a heat pipe receiver with thermal energy storage (TES) for use with a dish-Stirling solar power system in the 20-KWe power range, demonstrating technology that has potential for low-cost manufacture.
General Electric Company	F-3	High-Temperature Solar Thermal Receiver (Conceptual Design)	To conduct a study that will provide a conceptual design of a solar receiver for industrial processes and high-temperature applications, including high-temperature Brayton.
Sanders Associates, Inc.	F-4	High-Temperature Solar Thermal Receiver (Conceptual Design)	To conduct a study that will provide a conceptual design of a solar receiver for industrial processes and high-temperature applications, including high-temperature Brayton.
Sanders Associates	F-5	20-kWe Brayton Solar Power System Component Development	To provide for the design, fabrication, and testing of the thermal storage modules with their associated valving and testing of a high storage module with valving.

Table 6 (continued)

Contractor/Subcontractor	Project ID No.	Title	Objective
Solar Energy Research Institute	F-6	Heat Transfer and Receiver R&D	To develop receivers for high-temperature (600 °K) solar applications.
Solar Energy Research Institute	F-7	Performance Testing and Test Facility	To develop, operate, and maintain a versatile test facility.
Solar Energy Research Institute/ Dynatherm Corporation	F-8	Heat Pipe Receiver Test Module	To test a small heat pipe receiver module under actual flux conditions.
Solar Energy Research Institute/ University of Houston, Solar Energy Laboratory	F-9	Operational Support for the Solar Thermal Test Facility Users Association (STTFUA)	To provide support to STTFUA in disseminating information on, coordinating the use of, and arranging experimental findings for DOE solar test facilities at Sandia Laboratories and the Georgia Institute of Technology.
Solar Energy Research Institute/ Solar Turbines International	F-10	Advanced Solar Receivers High-Temperature Steam Loop Experiment	To investigate the use of high-temperature (1500 °F) steam systems for application to solar central receivers.
Solar Energy Research Institute/ Westinghouse Electric Corp.	F-11	Devise and Test Program for a Fluidized Bed of Solid Particles as a Solar Thermal Receiver	To investigate the application of fluidized bed technology to solar central receivers.

Table 7

G. Advanced Systems/Applications Projects

(Advanced Thermal Technology)

Contractor/Subcontractor	Project ID No.	Title	Objective
Energy Research and Generation, Inc.	G-1	Advanced Free-Piston Stirling Engine/15kWe Linear Alternator Study	To perform the preliminary design and analysis of critical components and subassemblies of a 15-kWe Stirling engine with a linear alternator.
Fairchild Industries, Inc., Fairchild Stratos Division/ Solar Turbines International; Georgia Institute of Technology; Institute of Gas Technology; United Sterling of Sweden	G-2	Design and Fabrication of the Dish-Stirling Solar Receiver	To demonstrate the technology for a minimum low-cost solar receiver, including fossil-fuel hybrid operation integrated with a Stirling-cycle engine alternator.
Solar Energy Research Institute/ Institute of Gas Technology	G-3	Decomposition of Cadmium Oxide as a Step in Solar Thermochemical Hydrogen Production	To quantify the decomposition rate, temperature, and pressure of CdO in a solar-operated chemical reaction chamber.
Solar Energy Research Institute/ Princeton University	G-4	Flash Pyrolysis of Biomass Using Concentrated Solar Radiation	To develop hardward designs and process kinetic information to support the design of a prototype commercial unit.

Table 8

H. Supporting Programs Projects

(Advanced Thermal Technology)

Contractor/Subcontractor	Project ID No.	Title	Objective
Battelle Pacific Northwest Laboratories	H-1	Research and Development for Solar Mirror Quality Assurance and Performance	To support a solar reflector materials data base and develop new optical performance instrumentation and technologies.
Solar Energy Research Institute/ National Bureau of Standards	H-2	Thermal Radiation Properties Measurements	To develop standards of specular and directional hemispherical reflectance and establish National Bureau of Standards measurement capability.
Solar Energy Research Institute	H-3	Advanced Technology Program Management	To complete management decentralization of the DOE Advanced Technology Program.
Solar Energy Research Institute	H-4	Solar Thermal Technical Information Dissemination Project	To increase volume and utility of technical information and create an effective communications network.

FISCAL YEAR 1979

PROJECT SUMMARIES

DISTRIBUTED RECEIVER SYSTEMS

A. Point-Focusing Systems Project Summaries

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-1

CONTRACTOR/ADDRESS	TITLE
Acurex Corporation Alternate Energy Division 485 Clyde Avenue Mountain View, California 94042	Low-Cost Point-Focus Concentrator
	CONTRACT NO. 955208
PRINCIPAL INVESTIGATOR J. Vindum	PERIOD OF PERFORMANCE September 15, 1978 to March 16, 1979
WORK LOCATION Mountain View, California	FISCAL YEAR 1979 FUNDING $183,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $238,000

OBJECTIVE

The purpose of the project was to select, study, optimize, and perform a preliminary design of a point-focusing concentrator which has the potential, when mass produced, of attaining a performance/cost of 0.004 to 0.12 kWth/$. The primary objectives were to select an optimum set of design parameters to maximize kWth/$, perform a preliminary design based on selected parameters, establish preliminary interfaces with the rest of the system, and assess how to implement mass production of the selected design.

APPROACH

The Acurex Corporation was one of three contractors selected to perform a parameter optimization of its proposed concept to maximize the performance/cost ratio. The basic fixed-price contract covers the optimization study. A fixed-price option, funded in FY 1979, can be exercised to perform a preliminary design based upon the design parameters selected.

STATUS

This contract is completed. Results are documented in the report, "Low-Cost Point-Focus Solar Concentrator - Phase 1, Final Report," March 16, 1979.

FUTURE EFFORT

Follow-on Phase II/III activities will be carried out.

Both General Electric and the Acurex Corporation proposed for the follow-on Phase II/III competition. General Electric was selected for the contract and work started in August 1979.

Bibliography Reference No.: 1

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems

A-2

CONTRACTOR/ADDRESS	TITLE
Arthur D. Little, Inc. Acorn Park Cambridge, Massachusetts 02140	A Study of Mass Production and Industrialization of Small Solar Thermal Electric Power Systems
	CONTRACT NO. 955286
PRINCIPAL INVESTIGATOR J. Butterfield	PERIOD OF PERFORMANCE March 1, 1979 to September 26, 1979
WORK LOCATION Cambridge, Massachusetts 02140	FISCAL YEAR 1979 FUNDING $173,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $173,000

OBJECTIVE

The aims of this project are to investigate the means by which industry could produce and install point-focusing distributed receiver (PFDR) systems at minimum cost and to fully characterize the factors, issues, and problems inherent in the transfer of this technology to the industrial sector.

APPROACH

One PFDR system concept will be analyzed to obtain definitive information on the overall process of industrialization and the potential for cost reductions in production and installation.

STATUS

Two preliminary reports have been issued:

- "Comparative Industrialization Needs of Three Types of Solar Engines."--This report indicates that reciprocating steam engines can be made today with inplace capacity in other industries, while the Stirling engine will likely require specialized facilities both for subassembly manufacture and assembly. For production quantities of 1,000 units/year, the work, in large part, will be delegated to job shop subcontractors.

  For production quantities of 10,000 units/year, the component fabrication capital requirements amount to $3,000,000 for the steam Rankine engine and $6,000,000 for the Stirling engine. For production quantities of 100,000 units/year, the capital costs are $7,000,000 for the steam Rankine engine and $18,000,000 for the Stirling engine.

ELEMENT: Distributed Receiver Systems

SUBELEMENT: Point-Focusing Systems A-2

CONTRACTOR/ADDRESS	TITLE
Arthur D. Little, Inc. Acorn Park Cambridge, Massachusetts 02140	A Study of Mass Production and Industrialization of Small Solar Thermal Electric Power Systems
	CONTRACT NO. 955286
PRINCIPAL INVESTIGATOR J. Butterfield	PERIOD OF PERFORMANCE March 1, 1979 to September 26, 1979
WORK LOCATION Cambridge, Massachusetts 02140	FISCAL YEAR 1979 FUNDING $173,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $173,000

(continued)

- "Process Analysis for Manufacturing Cellular Glass."--This report analyzed all of the items required to produce "cellular glass," i.e., raw materials, processes, and costs. The report estimates that the fixed capital investment for a Foamglas (TM), as produced by Pittsburgh Corning Corporation, pane production facility capable of making 50,000 units/year is $22,700,000. A facility capable of producing 500,000 units/year would cost $108,000,000.

FUTURE EFFORT

Industrialization and mass-production costing of the Brayton engine and PFDR collector will be studied.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems

A-3

CONTRACTOR/ADDRESS The BDM Corporation 915 Jones Branch Drive McLean, Virginia 22102	TITLE A Workshop for Potential Users of Solar Thermal Electric Power Systems in Military and Related Civil Sector Markets
	CONTRACT NO. 755354
PRINCIPAL INVESTIGATOR J. S. Hauger	PERIOD OF PERFORMANCE February 12, 1979 to December 12, 1979
WORK LOCATION McLean, Virginia 22102	FISCAL YEAR 1979 FUNDING $65,500
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $65,500

OBJECTIVE

The objective of this project is twofold:

- To define isolated military and related civil applications, plant requirements, and market sizes for solar thermal electric power systems.
- To bring together potential users of solar thermal electric power systems.

APPROACH

This project has entailed (1) conducting a study to define isolated military and related civil applications, plant requirements, and market sizes; and (2) conducting a workshop for potential users of solar thermal electric power systems.

STATUS

A workshop was held at BDM Corporation headquarters on September 10-14, 1979. Results of the BDM study were presented at the workshop. The results of the workshop will be presented in detail in the Proceedings document, now in preparation.

The BDM study resulted in the following determinations:

- The Army, Navy, Air Force, and Marine Corps currently maintain an inventory of approximately 1,800 MW with an annual procurement potential of 140 MW for power systems rated 15 kW and larger. The plant requirements of all these systems can potentially be met by advanced heat engines of the types under development for point-focus distributed-receiver (PFDR) application. Solar-provided heat is consistent with approximately 33 MW annual procurement. An additional 30 MW per year could be used if the Department of Defense seeks self-sufficiency of mission-critical facilities.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-3

CONTRACTOR/ADDRESS The BDM Corporation 915 Jones Branch Drive McLean, Virginia 22102	TITLE A Workshop for Potential Users of Solar Thermal Electric Power Systems in Military and Related Civil Sector Markets
	CONTRACT NO. 755354
PRINCIPAL INVESTIGATOR J. S. Hauger	PERIOD OF PERFORMANCE February 12, 1979 to December 12, 1979
WORK LOCATION McLean, Virginia 22102	FISCAL YEAR 1979 FUNDING $65,500
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $65,500

(continued)

- Total military power purchased from utilities is the equivalent of approximately 5,000 MW in generating capacity. If Congress were to authorize the capital expense for total base self-sufficiency, an additional 220 MW annual market would result. Cogenerating systems would increase the demand.

- Cost goals vary with assumptions, but a baseline case assuming 8 percent real fuel escalation indicates busbar cost goals of 120-210 mills/kWh, depending on size, for military generators and 86 mills/kWh for purchased electricity. This indicates a PFDR system installed cost goal of $2,500-$2,700 for average insolation areas.

FUTURE EFFORT

No future effort is planned.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-4

CONTRACTOR/ADDRESS	TITLE
Boeing Engineering & Construction Co. P. O. Box 3707 Seattle, Washington 98129	Low-Cost Point Focus Concentrator
	CONTRACT NO. 955209
PRINCIPAL INVESTIGATOR D. K. Zimmerman	PERIOD OF PERFORMANCE September 15, 1978 to March 16, 1979
WORK LOCATION Seattle, Washington	FISCAL YEAR 1979 FUNDING $184,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $240,000

OBJECTIVE

The goal of this project was to select, study, optimize, and perform preliminary design of a point focusing concentrator which has the potential, when mass produced, of attaining a performance/cost of 0.004 to 0.012 kWth/$. The primary objectives were to select an optimum set of design parameters to maxmize kWth/$, perform a preliminary design based on selected parameters, establish preliminary interfaces with the rest of the system, and assess how to implement mass production of the selected design.

APPROACH

The Boeing Corporation was one of three contractors selected to perform a parameter optimization of its proposed concept to maximize the performance/cost ratio. The basic fixed-price contract covered the optimization study. A fixed-price option, funded in FY 1979, allowed for the creation of a preliminary design based upon the design parameters selected.

STATUS

This contract is completed. Results are documented in the report "Low-Cost Point-Focus Concentrator - Phase 1, Final Report," March 1979.

Both General Electric (GE) and the Acurex Corporation proposed for the follow-on Phase II/III competition. GE was selected for the contract and work started in August 1979.

FUTURE EFFORT

Follow-on Phase II/III activities will be carried out.

Bibliography Reference No.: 2

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-5

CONTRACTOR/ADDRESS	TITLE
E-Systems, Inc. P. O. Box 226118 Dallas, Texas 75266	Test-Bed Concentrator
	CONTRACT NO. 955191
PRINCIPAL INVESTIGATOR V. Goldberg	PERIOD OF PERFORMANCE September 13, 1979 to November 15, 1979
WORK LOCATION Energy Technology Center Garland, Texas 75040	FISCAL YEAR 1979 FUNDING $278,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $653,000

OBJECTIVE

The purpose of this contract is to procure two test-bed concentrators to be used for point-focus concentrator development and testing at the subsystem and module level.

APPROACH

An existing antenna design is to be modified to satisfy the Jet Propulsion Laboratory (JPL) requirements for a test-bed concentrator. The reflector surface will be made up of JPL-supplied mirror facets with Foamglas (TM) substrates. The contractor will do the required design modification, fabrication, installation, and checkout.

STATUS

The design is completed. Installation at the Parabolic Dish Test Site at the Edwards Test Station in California is 80% complete.

FUTURE EFFORT

Installation will be complete in the 1st Quarter of FY 1980. No future work is planned under this contract.

Subcontractors: Electrospace Systems, Inc.; ALCO Machine Company

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-6

CONTRACTOR/ADDRESS	TITLE
The Garrett Corporation AiResearch Manufacturing Company of California 2525 West 190th Street Torrance, California 90509	Phase II of the Air Brayton Solar Receiver (ABSR)
	CONTRACT NO. 955136
PRINCIPAL INVESTIGATOR M. Greeven	PERIOD OF PERFORMANCE May 31, 1979 to March 31, 1980
WORK LOCATION Torrance, California	FISCAL YEAR 1979 FUNDING $170,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $433,111

OBJECTIVE

The objective of this project is to design and fabricate prototype solar receivers for use in open-cycle air Brayton systems.

APPROACH

The Garrett Corporation was selected for this contract from among four Phase I receiver contractors. This Phase II contract includes final design, prototype fabrication, and bench testing of a 1500 ^{o}F, 85kWth, low-pressure (~35 psig) cavity receiver. These receivers will be utilized on the test-bed concentrators at the Parabolic Dish Test Site (PDTS) at Edwards, California.

STATUS

A detailed design review was completed on September 28, 1979.

FUTURE EFFORT

Fabrication and testing will begin immediately. Prototype fabrication and bench testing will be complete by March 31, 1980. After delivery to the PDTS, the receivers will be tested under actual field conditions.

ELEMENT: Distributed Receiver Systems

SUBELEMENT: Point-Focusing Systems

A-7

CONTRACTOR/ADDRESS	TITLE
The Garrett Corporation AiResearch Manufacturing Company of California 2525 West 190th Street Torrance, California 90509	Phase II of the Steam Rankine Solar Receiver (SRSR) CONTRACT NO. 955157
PRINCIPAL INVESTIGATOR M. Greeven	**PERIOD OF PERFORMANCE** June 15, 1979 to April 15, 1980
WORK LOCATION Torrance, California	**FISCAL YEAR 1979 FUNDING** $184,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	**CUMULATIVE FUNDING** $452,368

OBJECTIVE

The purpose of this project is to design and fabricate prototype solar receivers for use in steam Rankine systems.

APPROACH

The Garrett Corporation was selected for this follow-on contract over another Phase I receiver contractor. This Phase II contract includes final design, prototype fabrication, and bench testing of a 1000 - 1200 ^{o}F, 85 kWth, 2000 psig cavity receiver. Reheat capability is also a concern. These receivers will be utilized on the test-bed concentrators at the Point-Parabolic Dish Test Site (PDTS) at Edwards, California.

STATUS

A detailed design review is scheduled for October 11, 1979.

FUTURE EFFORT

Fabrication and testing will begin immediately. Prototype fabrication and bench testing will be complete by March 31, 1980. After delivery to the PDTS, the receivers will be tested under actual field conditions.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems

A-8

CONTRACTOR/ADDRESS	TITLE
General Electric Company P. O. Box 8555 Philadelphia, Pennsylvania 19101	The Effect of System Factors on the Economics of and the Demand for Small Solar Thermal Power Systems
	CONTRACT NO. 955273
PRINCIPAL INVESTIGATOR H. Goff	PERIOD OF PERFORMANCE December 13, 1978 to April 1, 1980
WORK LOCATION Philadelphia, Pennsylvania	FISCAL YEAR 1979 FUNDING $100,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $100,000

OBJECTIVE

This project aims to estimate the rate of market penetration for solar thermal technology in selected market sectors as a function of time, solar system factors, and market/economic considerations, and to develop cost-effective strategies for accelerating the rate of market penetration in the more promising near-term markets.

APPROACH

Market surveys are to be conducted through General Electric field divisions. A demand market penetration model is to be developed to perform a market penetration sensitivity analysis.

STATUS

The preliminary results of a mail survey (based on 22% response to an industrial survey and 9% response to a utility survey) were compiled as of August 1979. This survey indicated that:

- The largest projected increase over the next 10 years in industrial electrical requirements is expected to occur in the Southwestern United States.
- Industries expect the availability of oil and gas in 1990 to be partially to severely limited.
- The predominant criteria listed by industrial respondents as impacting the solar system capital investment decision were the initial price/kW, the availability of loan guarantees and other mechanisms to reduce the risk, and the availability and cost of land.

ELEMENT: Distributed Receiver Systems

SUBELEMENT: Point-Focusing Systems A-8

CONTRACTOR/ADDRESS	TITLE
General Electric Company P.O. Box 855 Philadelphia, Pennsylvania 19101	The Effect of System Factors on the Economics of the the Demand for Small Solar Thermal Power Systems
	CONTRACT NO. 955273
PRINCIPAL INVESTIGATOR H. Goff	PERIOD OF PERFORMANCE December 13, 1978 to April 1, 1980
WORK LOCATION Philadelphia, Pennsylvania	FISCAL YEAR 1979 FUNDING $100,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $100,000

(continued)

- Solar systems were viewed by industrial respondents as valuable insofar as they provide protection against fuel price escalation and ruel curtailment; they provide a means and a justification for the repowering of existing plants.
- Based on company needs and solar system benefits and limitations, 51% of the industrial respondents and 9% of the utility respondents stated that a solar system would be an option their company would consider in the 1990 time period.

FUTURE EFFORT

Contract activities will be continuing.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-9

CONTRACTOR/ADDRESS	TITLE
General Electric Company Space Division King of Prussia Park P. O. Box 8661 Philadelphia, Pennsylvania 19101	Low-Cost Point-Focus Concentrator
	CONTRACT NO. 955210
PRINCIPAL INVESTIGATOR J. Zimmerman	PERIOD OF PERFORMANCE September 15, 1978 to March 1979
WORK LOCATION Philadelphia, Pennsylvania	FISCAL YEAR 1979 FUNDING $184,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $239,000

OBJECTIVE

The purpose of this project was to select, study, optimize, and perform preliminary design of a point-focusing concentrator which has the potential, when mass produced, of attaining a performance/cost of 0.004 to 0.012 kWth/$. The primary objectives were to select an optimum set of design parameters to maximize kWth/$, perform a preliminary design based on selected parameters, establish preliminary interfaces with the rest of the system, and assess how to implement mass production of the selected design.

APPROACH

The General Electric (GE) Company was one of three contractors selected to perform a parameter optimization of its proposed concept to maximize the performance/cost ratio. The basic fixed-price contract covered the optimization study. A fixed-price option, funded in FY 1979, allowed for the creation of a preliminary design based upon the design parameters selected.

STATUS

This contract is completed. Results are documented in the report "Low-Cost Point-Focus Solar Concentrator - Final Study Report, Phase I, Preliminary Design."

GE and the Acurex Corporation proposed for the follow-on Phase II/III competition. GE was selected for the contract and work started in August 1979.

FUTURE EFFORT

Follow-on Phase II/III activities will be carried out.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-10

CONTRACTOR/ADDRESS	TITLE
General Electric Company Space Division King of Prussia Park P. O. Box 8661 Philadelphia, Pennsylvania 19101	Low-Cost Point-Focus Solar Concentrator, Phase II/III
	CONTRACT NO. 955509
PRINCIPAL INVESTIGATOR J. Zimmerman	PERIOD OF PERFORMANCE August 8, 1979 to December 31, 1980
WORK LOCATION Philadelphia, Pennsylvania	FISCAL YEAR 1979 FUNDING $360,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $1,378,000 + Award Fee

OBJECTIVE

The objective of this contract is to detail design, fabricate, and install three units at the Parabolic Dish Test Site (PDTS) and conduct checkout tests on the concentrator selected from proposals based on the three preliminary designs conducted in Phase 1. The concentrator is for use with a Brayton Receiver/Power Conversion Unit operating at 1500 ^{o}F. The concentrator may also be used for process heat applications.

APPROACH

Three concentrator units are to be detail designed, fabricated, and installed at the PFSTS, followed by checkout testing on the selected concentrator.

STATUS

Previous to this contract three contractors performed a parameter optimization and preliminary design - Phase I study. Two of the three contractors then proposed for the Phase II/III follow-on effort. General Electric was selected and the design activity of Phsae II is now underway.

FUTURE EFFORT

No future activities are planned under this contract. This concentrator design is a candidate for the Small Community Solar Thermal Power Experiment.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems

CONTRACTOR/ADDRESS	TITLE
General Electric Company Advanced Energy Programs P.O. Box 8661 Philadelphia, Pennsylvania 19101	Solar Total Energy Project Design for Shenandoah, Georgia Site
	CONTRACT NO. EG-77-C-04-3985
PRINCIPAL INVESTIGATOR A. J. Poche	PERIOD OF PERFORMANCE September 1, 1978 to August 30, 1979
WORK LOCATION King of Prussia, Pennsylvania	FISCAL YEAR 1979 FUNDING $3,627,156
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $9,454,579

OBJECTIVE

The aim of this project is fourfold:

- To develop engineering experience for later commercial-size applications of solar total energy systems.
- To acquire data to reduce risk in future cost and performance predictions.
- To assess interaction of technology in an industrial application with an electric utility system.
- To ensure dissemination of technical data.

APPROACH

The solar total energy system (STES) is being designed for a knitwear plant in Shenandoah, Goergia. It will supply over 50 percent of the energy requirements for the plant, including electric power, process steam, and space heating and cooling. Trade-off studies have resulted in the selection of a distributed collection/central generation STES configuration, using parabolic dish solar collectors, trickle oil thermal energy storage, and a steam Rankine power conversion subsystem with an extraction turbine prime mover.

STATUS

The project was rescoped from a 192-dish collector system to provide the energy needs of a 42,000 ft^2 plant to a 120-dish for the present 25,000 ft^2 plant. The project is in the final stages of the definitive design phase. A quadrant of 7-meter prototype dish collectors is under test and evaluation at the Midtemperature Solar System T

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-11

CONTRACTOR/ADDRESS	TITLE
General Electric Company Advanced Energy Programs P.O. Box 8661 Philadelphia, Pennsylvania 19101	Solar Total Energy Project Design for Shenandoah, Georgia Site
	CONTRACT NO. EG-77-C-04-3985
PRINCIPAL INVESTIGATOR A. J. Poche	PERIOD OF PERFORMANCE September 1, 1978 to August 30, 1979
WORK LOCATION King of Prussia, Pennsylvania	FISCAL YEAR 1979 FUNDING $3,627,156
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $9,454,579

(continued)

Facility at Sandia Laboratories in Albuquerque, New Mexico. An extended column storage system test was conducted with iron ore to be used in the Shenandoah application. Fluid tests for compatibility with different materials have been conducted. Further tests to obtain fluid loss data are being conducted. Alternative reflective surfaces are being investigated for the collector. Final design drawings and specifications are being processed to provide early issuance of construction bid packages where necessary to realize the January 1982 operational date. The turbine-generator design has been completed and parts have been fabricated to permit testing during the first quarter of FY 1980.

FUTURE EFFORT

The definitive design phase is scheduled to be completed by December 31, 1979. Long-lead procurement of components and material will be initiated to expedite availability for the construction phase beginning January 1, 1980. Collector design changes elicited by the current MSSTF tests will be integrated into the construction phase design. Turbine-generator test data will permit utility interface details to be resolved. Construction phase contractual arrangements will be completed.

Subcontractor: Lockwood-Greene, Architects & Engineers

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point - Focusing Systems

A-1

CONTRACTOR/ADDRESS	TITLE
Georgia Power Company P.O. Box 4545 Atlanta, Georgia 30302	Solar Total Energy Project at Shenandoah, Georgia
	CONTRACT NO. EG-77-A-04-3994
PRINCIPAL INVESTIGATOR R. Hensley	PERIOD OF PERFORMANCE June 14, 1977 to August 31, 1979
WORK LOCATION Atlanta, Georgia	FISCAL YEAR 1979 FUNDING $352,520
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $832,244

OBJECTIVE

This project has four major objectives:

- To develop engineering experience for later commercial-size applications.
- To acquire data to reduce risk in future cost and performance predictions.
- To assess interaction of technology in an industrial application with an electri utility system.
- To ensure dissemination of technical data.

APPROACH

To achieve the objectives, the following services are required:

- Analyzation of factory energy needs, utilization, conservation, and performance.
- Instrumentation of the factory and provision of data.
- Provision of engineering services, utilities, site data, interface documentation, an materials and services for pipes and wires from the solar total energy system sit to the factory.
- Operation of a meteorology station.
- Assistance to DOE/Sandia in information dissemination.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-12

CONTRACTOR/ADDRESS	TITLE
Georgia Power Company P.O. Box 4545 Atlanta, Georgia 30302	Solar Total Energy Project at Shenandoah, Georgia
	CONTRACT NO. EG-77-A-04-3994
PRINCIPAL INVESTIGATOR R. Hensley	PERIOD OF PERFORMANCE June 14, 1977 to August 31, 1979
WORK LOCATION Atlanta, Georgia	FISCAL YEAR 1979 FUNDING $352,520
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $832,244

(continued)

STATUS

The site has been graded and grassed. Factory and meteorology data covering more than a year of operation has been obtained. On-site collector foundation sizing tests have been conducted with a potential cost savings in material requirements.

FUTURE EFFORT

The second quarter of FY 1980 will herald the initiation of construction activities on-site. Further building and meteorology data will be collected and analyzed. Further coordination with the design team will be effected to facilitate a smooth transition into the construction phase of the project.

Subcontractors: Shenandoah Development, Inc.; Georgia Institute of Technology; Heery and Heery Inc.; Owens-Corning Fiberglass; Westinghouse Electric Corp.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems

A-12

CONTRACTOR/ADDRESS	TITLE
Pioneer Engineering and Manufacturing Company 2500 E. Nine Mile Road Warren, Michigan 48091	Test-Bed Concentrator Cost Analysis
	CONTRACT NO. 955581
PRINCIPAL INVESTIGATOR R. Fortgang	PERIOD OF PERFORMANCE October 1, 1979 to April 1, 1980
WORK LOCATION Warren, Michigan	FISCAL YEAR 1979 FUNDING $50,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $80,000

OBJECTIVE

The aim of this project is to obtain independent cost analysis of the Point-Focus Distributed Receiver (PFDR) Test-Bed Concentrator.

APPROACH

Industry assistance will be obtained to analyze and estimate the cost of the Test-Bed Concentrator.

STATUS

Work is scheduled to begin on or about October 1, 1979.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-14

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Comparative Ranking of 0.1 to 10 MWe Small Solar Thermal Power Systems
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR J. P. Thornton	PERIOD OF PERFORMANCE April 1978 to September 1979
WORK LOCATION Golden, Colorado	FISCAL YEAR 1979 FUNDING $330,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $330,000

OBJECTIVE

The purpose of this project is to conduct a study in order to identify the most likely options for long-term commercialization of small solar thermal electric power systems by a comparative analysis of the major generic solar thermal electric systems. The main objective of the Small Solar Thermal Electric Power Systems Study is to project the mid-1990 cost and performance of selected generic solar thermal electric power systems for utility applications and to rank these systems using a set of seven criteria which reflect the most important aspects of their future commercial acceptability.

APPROACH

Plants with rated capacities of 0.1 to 10 MWe, operating over a range of capacity factors from the no-storage case to 0.7 and above, are considered in this study. The study is composed of three phases. The first phase involves the selection of generic systems and their variations, the establishment of ground rules, the selection of a simulation technique for projecting future cost and performance, and the definition of a suitable ranking methodology. The second phase entails the examination of systems of from 0.1 to 10 MWe rated capacity. The last phase considers smaller systems with rated capacities of 0.1 to 1.0 MWe.

STATUS

The Small Solar Thermal Electric Power Systems Study was initiated in April 1978 as parallel efforts at both SERI and Battelle Pacific Northwest Laboratories. The conclusions of the study were released in a series of reports between July and October 1979. A summary of the ranking of 1.0 to 10.0 MWe systems is included in the first volume. The second summary volume, covering the ranking 0.1 to 1.0 MWe systems, was released in October 1979. Supporting data volumes containing extensive discussions of the generic systems designs, the methodology, and the results and conclusions were also released at that time.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-14

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Comparative Ranking of 0.1 to 10 MWe Small Solar Thermal Power Systems
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR J. P. Thornton	PERIOD OF PERFORMANCE April 1978 to September 1979
WORK LOCATION Golden, Colorado	FISCAL YEAR 1979 FUNDING $330,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $330,000

(continued)

FUTURE EFFORT

The technique of comparative ranking developed during this task will be used for systems applicable to nonelectric uses.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-15

CONTRACTOR/ADDRESS	TITLE
Sun Power Corporation 55 Miller Street Fairfield, Connecticut 06130	Solar Concentrator Module Fold-up Unit: Design and Fabrication
	CONTRACT NO. 955564
PRINCIPAL INVESTIGATOR C. Whiteford	PERIOD OF PERFORMANCE September 28, 1979 to September 29, 1980
WORK LOCATION Fairfield, Connecticut	FISCAL YEAR 1979 FUNDING $42,621
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $42,621

OBJECTIVE

The objective of this contract is to perform the design, engineering, fabrication, and test of a concentrator concept that would improve the efficiency, accuracy, and costs of the concentrator.

APPROACH

A detail design of all of the components that are needed to make a full-scale, operable structure will be performed.

STATUS

The contract has been initiated.

FUTURE EFFORT

Future activities will entail finishing the design, fabrication, and test of the concept.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems

CONTRACTOR/ADDRESS	TITLE
Science Applications, Inc. 1400 Westpark Drive McLean, Virginia 22102	Solar Thermal Plant Impact Analysis and Requirements Definitions Study
	CONTRACT NO. 955238
PRINCIPAL INVESTIGATOR Y. P. Gupta	PERIOD OF PERFORMANCE November 1, 1978 to December 31, 1980
WORK LOCATION McLean, Virginia 22102	FISCAL YEAR 1979 FUNDING $255,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $255,000

OBJECTIVE

The aim of this contract is to conduct an impact analysis and requirements definition of solar thermal electric power systems in utility and nonutility applications.

APPROACH

Four tasks are required in pursuing the objective:

- Develop data bases for solar thermal power systems, loads, and regions.
- Select several combinations for initial utilization in the impact analysis and requirements definition.
- Devise methodology on the basis of initial combination results.
- Complete an impact analysis and requirements definition study for a total of 10 combinations of system/application/region.

STATUS

The first three tasks, involving data base development, have been completed. Results are as follows:

On the basis of extensive analysis, the point-focusing distributed receiver (PFDR) concept was selected for initial use in the impact analysis and requirements definition. Two basic configurations will be analyzed: PFDR with distributed generation (focal-mounted turbine/generator) and PFDR with central generation (thermal energy transport to a central turbine/generator). Inititally, Brayton, Stirling, and combined cycles will be considered for the distributed generation mode, possible with hybrid and electrical storage. Only Rankine cycles will be considered for the central generation mode because (a) large heat losses are typically associated with the thermal transport, and (b) Rankine

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Point-Focusing Systems A-16

CONTRACTOR/ADDRESS	TITLE
Science Applications, Inc. 1400 Westpark Drive McLean, Virginia 22102	Solar Thermal Plant Impact Analysis and Requirements Definitions Study
	CONTRACT NO. 955238
PRINCIPAL INVESTIGATOR Y. P. Gupta	PERIOD OF PERFORMANCE November 1, 1978 to December 31, 1980
WORK LOCATION McLean, Virginia 22102	FISCAL YEAR 1979 FUNDING $255,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $255,000

(continued)

turbines are more efficient in the larger sizes. Chemical transport will not be treated in the initial analysis because it is in an early stage of testing and technology development. Thermal storage will be considered for the central generation mode.

Baseline applications selected for initial analysis were (1) four Electric Power Research Institute synthetic utilities sited in the Northwest, Southwest, South Central, and South Central U.S., respectively; (2) industrial loads (three-shift and one-shift) sited in both the Northeast and Southwest; and (3) military installations (Science Appplications, Inc.-developed synthetic load profile) sited in the Northeast and Southwest.

FUTURE EFFORTS

An impact analysis and requirements definition will be performed.

Subcontractor: Black & Veatch Consulting Engineers

DISTRIBUTED RECEIVER SYSTEMS

B. Line-Focusing Systems
Project Summaries

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems B-1

CONTRACTOR/ADDRESS	TITLE
Acurex Corporation 485 Clyde Avenue Mountain View, California 94042	150 kWe Solar-Powered Deep-Well Irrigation Facility
	CONTRACT NO. EG-77-C-04-4159
PRINCIPAL INVESTIGATOR D. Rafinejad	PERIOD OF PERFORMANCE September 30, 1977 to September 29, 1979
WORK LOCATION Mountain View, California Coolidge, Arizona	FISCAL YEAR 1979 FUNDING $2,800,000
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $5,460,000

OBJECTIVE

The purpose of this project is to design, construct, and operate for checkout and data-gathering a solar-powered experimental facility to provide 150 kW of electric power for the operation of deep-well irrigation pumps.

APPROACH

Acurex, which was awarded this contract upon completion of a competitive preliminary design study phase conducted in FY 1977, is working cooperatively with DOE and the State of Arizona on this project. Arizona is providing the facility site, located on a farm in Coolidge, Arizona, and will conduct agricultural experimentation.

Acurex will perform a detailed design, construct the solar system, and perform initial checkout and operation of the facility.

STATUS

A detailed design was completed in June 1978 and construction was begun in August 1978. Initial checkout took place in August 1979 and initial operation is scheduled for September 21, 1979.

FUTURE EFFORT

Upon completion of check-out by Acurex Corporation, the facility will be operated by the University of Arizona under contract to Sandia for the purpose of measuring performance and operations and maintenance (O&M) data.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems

CONTRACTOR/ADDRESS University of Arizona Optical Science Center Tucson, Arizona 85721	TITLE Technology Assessment Study of Small Module Fixed-Mirror Distributed-Focus (FMDF) Photothermal Concentrators
	CONTRACT NO. 955162
PRINCIPAL INVESTIGATOR A. Meinel	PERIOD OF PERFORMANCE September 1978 to June 1980
WORK LOCATION Tucson, Arizona	FISCAL YEAR 1979 FUNDING $48,333
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $48,333

OBJECTIVE

The purpose of this project was to perform a comparative analysis of small module fixed-mirror distributed-focus (FMDF) photothermal concentrators with other existing fixed-mirror designs to produce a low-cost, high-performance, long-term stabilized concept.

APPROACH

The fully tracking paraboloid was used as a baseline to make an engineering evaluation of the mirror structure and of the key parameters that affect the cost, performance, and stability of small module FMDF concentrators.

STATUS

The analysis has been completed.

FUTURE EFFORTS

The Jet Propulsion Laboratory is considering further funding to extend the project analysis for Fresnel and other concentrators.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems

B-3

CONTRACTOR/ADDRESS	TITLE
Oak Ridge National Laboratory Union Carbide Corporation P. O. Box X Oak Ridge, Tennessee 37830	Small Solar Power Systems Mission Analysis
	CONTRACT NO. W-7405-eng-26
PRINCIPAL INVESTIGATOR C. G. Lawson and M. A. Karnitz	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Oak Ridge, Tennessee	FISCAL YEAR 1979 FUNDING $481,000
CONTRACTING OFFICE Oak Ridge Operations Oak Ridge, Tennessee	CUMULATIVE FUNDING $781,000

OBJECTIVE

This project aims to provide program planning and analytical support for implementation of the Small Solar Thermal Power Systems Program Plan. Specific objectives involve identification of (1) appropriate markets; (2) attractive small solar plant configurations; (3) needed technology development; and (4) the technical, financial, institutional, and social factors that favor the use of small solar power systems.

APPROACH

Planning and analysis support of DOE programs includes review and evaluation of market penetration, applications, and related mission analysis and support for large-scale experiments. Systems analysis is being extended by comparing combinations of solar plants with other on-site power generation and grid connections for the industrial and residential sectors.

STATUS

To date, the following tasks have been accomplished:

- Recent market penetration studies were reviewed and the solar power potential was estimated.
- Recent heliostat production cost estimates were reviewed.
- Developments in heat engine improvements related to solar plants were reviewed.
- Solar total energy was compared with fossil total energy systems in selected industrial applications.
- A workshop was held on market diffusion of innovation applied to solar power plants.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems B-3

CONTRACTOR/ADDRESS	TITLE
Oak Ridge National Laboratory Union Carbide Corporation P. O. Box X Oak Ridge, Tennessee 37830	Small Solar Power Systems Mission Analysis
	CONTRACT NO. W-7405-eng-26
PRINCIPAL INVESTIGATOR C. G. Lawson and M. A. Karnitz	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Oak Ridge, Tennessee	FISCAL YEAR 1979 FUNDING $481,000
CONTRACTING OFFICE Oak Ridge Operations Oak Ridge, Tennessee	CUMULATIVE FUNDING $781,000

(continued)

- o A draft of a handbook for evaluating solar total energy systems for industrial applications was completed.
- o An evaluation of high-temperature solar total energy applications potential and penetration was completed.
- o User's guides were prepared and published for the solar total energy system, applications, and market penetration models.

Subcontractors: The Aerospace Corporation

Bibliography Reference No.: 3

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems

CONTRACTOR/ADDRESS	TITLE
Sandia Laboratories P. O. Box 5800 Albuquerque, New Mexico 87185	Midtemperature Component and Subsystem Development Project
	CONTRACT NO. AT (29-1)-0789
PRINCIPAL INVESTIGATOR J. F. Banas	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $4,002,000
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $8,582,000

OBJECTIVE

The objective of this project is to develop line-focus concentrating collector subsystems (i.e., collector, storage, and power conversion subsystems) with high performance, durability, and reliability utilizing mass-production technology with potential for low cost.

APPROACH

Activities are being pursued in the following areas: 1) subsystem engineering, 2) materials and process development, 3) line-focus collector development, 4) storage development, 5) prime mover development, and 6) operation and maintenance characterization.

STATUS

The following activities have been carried out:

- An engineering prototype trough was fabricated and tested to demonstrate improved performance potential of 60% peak noontime efficiency at 312 ^{o}C.
- Large (2m x 6m) steel-skinned/aluminum-cored honeycomb structures were fabricated for the engineering prototype trough. (Subcontractor/cost: Hexcel/$95K.)
- Sagged glass and chemically strengthened glass were demonstrated in trough structures. (Subcontractor/Cost: Standard Bent Glass Company/$10K; Corning Glass Company/$45K; Carolina Mirror Corporation/$5K.)
- An aperture-based (hot wire/microprocessor) tracker was demonstrated.
- A sealed/unevacuated receiver was demonstrated.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems B-4

CONTRACTOR/ADDRESS	TITLE
Sandia Laboratories P. O. Box 5800 Albuquerque, New Mexico 87185	Midtemperature Component and Subsystem Development Project
	CONTRACT NO. AT (29-1)-0789
PRINCIPAL INVESTIGATOR J. F. Banas	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $4,002,000
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $8,582,000

(continued)

- Developments were initiated for gravity-sagged and press-formed glass made on automotive windshield-type production tooling. (Subcontractor/Cost: Ford Motor Company/$100K; Pittsburgh Plate Glass/$25K.)
- Layouts of troughs utilizing mass-production technologies were initiated.
- Field piping layout was developed for a modular trough collector subsystem. (Subcontractor/Cost: Jacobs-Del Engineering/$50K.)
- Trough foundation design study and testing were completed. (Subcontractor/Cost: Higgings & Auld/$20K.)
- Wind tunnel testing of scaled trough arrays was completed. (Subcontractor/Cost: Colorado State University/$40K.)
- Prototype development of trough structures of sheet metal and SMC from pseudo-production tooling was initiated. (Subcontractor/Cost: Budd Company/$300K (sheet metal); Haveg/$50K (SMC); Budd Company/$210K (SMC).)
- A plating process for improved black chrome selective coating was established for production. (Subcontractor/Cost: Highland Plating/$10K; Harshaw Chemical/$5K.)
- An Optical Measurements Workshop was sponsored to develop sources for testing labs.
- An environmental evaluation of candidate structural materials was completed.
- A thermocline storage subsystem was designed for engineering evaluation.
- An improved cogeneration steam turbine was assembled for the Shenandoah total energy project. (Subcontractor/Cost: MTI/$900K.)

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems B-4

CONTRACTOR/ADDRESS	TITLE
Sandia Laboratories P. O. Box 5800 Albuquerque, New Mexico 87185	Midtemperature Component and Subsystem Development Project
	CONTRACT NO. AT (29-1)-0789
PRINCIPAL INVESTIGATOR J. F. Banas	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $4,002,000
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $8,582,000

(continued)

- o A collector cleaning investigation was completed. (Subcontractor/Cost: McDonnell Douglas Aerospace Corporation/$100K.)

FUTURE EFFORT

The following activities are planned:

- o An engineering prototype trough evaluation is to be completed.
- o Prototype sheet metal, sheet molding compound, and sandwich structures are to be evaluated.
- o A mass-production bonding technique is to be established for the reflector structure.
- o Long-term environmental testing of the receiver is to be completed.
- o A prototype tracker/controller, a prototype drive, and a prototype flexible hose are to be evaluated.
- o A production prototype trough assembly is to be initiated.
- o A Black Chrome Plating Process Handbook is to be completed.
- o An evaluation of multitank and thermocline storage subsystems is to be completed.
- o Testing of a steam extraction turbine for the Shenandoah total energy project is to be completed.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems

B-5

CONTRACTOR/ADDRESS	TITLE
Sandia Laboratories P. O. Box 5800 Albuquerque, New Mexico 87185	Midtemperature Solar Systems Test Facility (MSSTF)
	CONTRACT NO. AT (29-1)-0789
PRINCIPAL INVESTIGATOR J. V. Otts	PERIOD OF PERFORMANCE October 1, 1979 to September 30, 1980
WORK LOCATION Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $3,232,000
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $18,109,000

OBJECTIVE

The goal of this project is to operate and maintain a test facility for concentrating solar collectors (as well as other subsystems). The project will (1) identify design and system integration considerations, (2) characterize performance and cost of solar energy components and subsystems, and (3) accumulate operational and maintenance experience applicable to a wide range of dispersed solar power systems application projects.

APPROACH

The Midtemperature Solar Systems Test Facility (MSSTF) and the various research and development (R&D) projects within the Solar Thermal Power Systems Program support application projects. Components are developed under the R&D efforts based on projected requirements of DOE or commercial application projects. The MSSTF is utilized as a test bed to evaluate these components and to identify, through operating experience, areas requiring additional research and development.

Tasks are being pursued in the following areas: (1) program management, (2) system management, (3) collector subsystems, (4) collector subsystems subcontracting, (5) high temperature storage subsystems, (6) prime mover subsystems, (7) heating and cooling subsystems, and (8) the solar collector module test facility.

STATUS

Evaluation has been completed on the following: (1) the total energy system, (2) the General Atomics collector subsystem, (3) the SUNTEC collector subsystem, (4) a thermocline tank mod #1, and (5) the Sandia Laboratories original trough (1975). Work has begun on (1) Custom

ELEMENT: Distributed Receiver Systems

B-ELEMENT: Line-Focusing Systems B-5

CONTRACTOR/ADDRESS	TITLE
Sandia Laboratories P. O. Box 5800 Albuquerque, New Mexico 87185	Midtemperature Solar Systems Test Facility (MSSTF)
	CONTRACT NO. AT (29-1)-0789
PRINCIPAL INVESTIGATOR J. V. Otts	PERIOD OF PERFORMANCE October 1, 1979 to September 30, 1980
WORK LOCATION Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $3,232,000
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $18,109,000

(continued)

Engineering troughs, (2) Sandia Laboratories receivers, (3) General Electric dishes (Shenandoah prototype), (4) a thermocline tank mod #2, (5) multitank storage subsystem, and (6) heat loss, control studies.

More than fifteen collectors/receivers have been characterized at the Collector Module Test Facility. Work is currently underway to qualify several commercial laboratories in order to increase solar program support. All completed subsystems, i.e., collectors, storage, turbine/generator, and heating and cooling subsystems, have been operating as a completed solar total energy system. The project continues to publish numerous reports and make presentations describing the evaluation of systems, subsystems and components, and tests related to subsystem losses. Also, approximately 700 visitors are hosted each month.

FUTURE EFFORT

Procurement and evaluation of candidate solar collectors and other subsystems for distributed receiver solar applications will continue. Completed subsystems will be removed and advanced subsystems will be installed in a continuously interactive mode.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems

CONTRACTOR/ADDRESS	TITLE
Sandia Laboratories P. O. Box 5800 Albuquerque, New Mexico 87185	Solar Energy Systems and Applications Development (Previously: Technical Management of Solar Total Energy Activities and Solar Irrigation Projects)
	CONTRACT NO. AT (29-1)-0789
PRINCIPAL INVESTIGATOR J. A. Leonard	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $1,435,000
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $6,728,000

OBJECTIVE

The project objective is to promote the use of solar power in on-site applications through experiments sponsored partially or wholly by DOE and performed in conjunction with the private sector. The experiments displace conventional power, provide focus for solar development, generate performance and cost data, and accumulate operating and maintenance experience.

APPROACH

Through this project, Sandia is providing technical management, engineering, and analytical support for projects within the Distributed Receiver (formerly, Small Solar Thermal Power) program element. Specific activities include advisory and planning support to DOE, technical direction and management support for DOE contracts, in-house and contracted solar development activities, and the development of analytical techniques for design evaluation of specific solar applications.

STATUS

Five projects are in process under this program element:

- The Solar Total Energy Large-Scale Experiment in Shenandoah, Georgia, is nearing completion of definitive design. This application will utilize parabolic-dish collectors for a 2,400 m^2 knitwear factory.
- The 150 kWe Solar Powered Deep-Well Irrigation Pumping Experiment in Coolidge, Arizona, will be operational in early fiscal year 1980. This project employs parabolic trough collectors.
- A 20-meter hemispheric bowl collector is being constructed at Crosbyton, Texas to develop the fixed-mirror, distributed-focus solar energy concept.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems B-6

CONTRACTOR/ADDRESS	TITLE
Sandia Laboratories P. O. Box 5800 Albuquerque, New Mexico 87185	Solar Energy Systems and Applications Development (Previously: Technical Management of Solar Total Energy Activities and Solar Irrigation Projects)
	CONTRACT NO. AT (29-1)-0789
PRINCIPAL INVESTIGATOR J. A. Leonard	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $1,435,000
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $6,728,000

(continued)

- The International Energy Agency is sponsoring a distributed solar collector system and a central tower system in Almeria, Spain. Sandia is providing technical support.
- The Agency for International Development is sponsoring a 38-kW solar irrigation project in Senegal, West Africa. Sandia is providing technical support.

On-going systems analysis and systems engineering subtasks are being conducted to provide technical input for evaluation and design of solar power systems for the projects described above and for future applications.

FUTURE EFFORT

Future planned activities include:

- Supporting a Small Solar Thermal Power Systems Contract Review and Line-Focus Collector Technology Workshop.
- Determining requirements of solar-enhanced oil recovery and estimating market potential for solar collectors and land availability.
- Completing the Shenandoah design and beginning construction.
- Dedicating the Coolidge project and beginning its operation.
- Completing the Crosbyton experimental test and beginning operation of the 20-meter collector.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems B-7

CONTRACTOR/ADDRESS	TITLE
Sandia Laboratories P. O. Box 5800 Albuquerque, New Mexico 87185	Solar Irrigation Facility Operation
	CONTRACT NO. AT (29-1)-789
PRINCIPAL INVESTIGATOR J. V. Otts	PERIOD OF PERFORMANCE October 1, 1979 to September 30, 1980
WORK LOCATION Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $600,000
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $600,000

OBJECTIVE

The objective of this contract is to manage projects to conduct (1) operation and maintenance, (2) testing, and (3) performance/cost analyses related to operating solar irrigation projects after construction.

APPROACH

Activities will include active participation in data collection and performance analysis as well as the management of the Operation and Maintenance (O&M) Contract with New Mexico State University, Battelle, and the University of Arizona for the Willard, Gila Bend, and Coolidge experiments, respectively.

STATUS

The 25 hp Shallow-Well Irrigation Pumping System at Willard, New Mexico, has been operational through FY 1979, accumulating in excess of 750 and 1,000 hours on the pumping and collector operation, respectively. New Mexico State University has the responsibility for O&M of the project.

The Gila Bend, Arizona, experimental system was reactivated under DOE authorization for a period of August to October 1979. Cumulative hours of pumping and collector operation total 775 hours through August 1979. Battelle was awarded the O&M contract for this project.

Construction of the Deep-Well Irrigation System at Coolidge, Arizona was scheduled for completion in October 1979. After checkout, the University of Arizona will resume O&M responsibility through FY 1980.

FUTURE EFFORT

Future plans include operation of the experimental systems at Willard, Gila Bend, and Coolidge at least through FY 1980.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems B-8

CONTRACTOR/ADDRESS	TITLE
Texas Tech University P. O. Box 4709 Lubbock, Texas 79409	Crosbyton Solar Power Project
	CONTRACT NO. DE-AC04-76ET20255 (Formerly EY-76-C-04-3737)
PRINCIPAL INVESTIGATOR J. D. Reichert	PERIOD OF PERFORMANCE September 1, 1976 to March 31, 1980
WORK LOCATION Lubbock, Texas	FISCAL YEAR 1979 FUNDING $1,416,361
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $4,303,585

OBJECTIVE

The aim of this project is to develop the fixed-mirror, distributed-focus (FMDF) solar energy concept and to demonstrate technical feasibility through design, construction, and test of a 20-meter prototype at Crosbyton, Texas.

APPROACH

The work of the project has been staged to allow careful evaluation and assessment of the concept merits at various times as the program progresses. The work of Segment I of Phase I involved a research and development effort which resulted in a conceptual design of a full-scale recommended power system (RPS) for Crosbyton. Segment I also produced a conceptual design of an analog design verification system (ADVS). Segment II of Phase I involves a continuation of the research and development program, including the construction and operation of the ADVS for the purpose of obtaining data to be used for refining performance predictions and economic analysis of the RPS. Phase II, which is conditional depending on DOE authorization, involves the construction of a 5 MWe power plant at Crosbyton.

STATUS

Segment I has been completed, and conceptual designs of the RPS and ADVS were reviewed by DOE at Texas Tech University in February 1978. Segment II was begun in June 1978. Design of the ADVS has been completed and construction is in process. The operational receiver underwent 10 hours of testing in the radiant heat facility at E-Systems, Inc. in September 1979.

ELEMENT: Distributed Receiver Systems

SUB-ELEMENT: Line-Focusing Systems

B-8

CONTRACTOR/ADDRESS	TITLE
Texas Tech University P. O. Box 4709 Lubbock, Texas 79409	Crosbyton Solar Power Project
	CONTRACT NO. DE-AC04-76ET20255 (Formerly EY-76-C-04-3737)
PRINCIPAL INVESTIGATOR J. D. Reichert	PERIOD OF PERFORMANCE September 1, 1976 to March 31, 1980
WORK LOCATION Lubbock, Texas	FISCAL YEAR 1979 FUNDING $1,416,361
CONTRACTING OFFICE Albuquerque Operations Office Albuquerque, New Mexico	CUMULATIVE FUNDING $4,303,585

(continued)

FUTURE EFFORT

Construction of the ADVS will be completed in the first quarter of FY 1980. Evaluation and testing of the ADVS is scheduled for completion during the second quarter of FY 1980.

Subcontractors: E-Systems, Inc., Energy Technology Center; Foster Wheeler Development Corporation

CENTRAL RECEIVER SYSTEMS

C. Systems and Applications Project Summaries

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-1

CONTRACTOR/ADDRESS	TITLE
Aerospace Corporation P. O. Box 9257 Los Angeles, California 90009	Systems Engineering Studies and Program Technical Support
	CONTRACT NO. 03-79ET21060
PRINCIPAL INVESTIGATOR H. Bernstein	PERIOD OF PERFORMANCE July 3, 1979 to November 30, 1979
WORK LOCATION Los Angeles, California	FISCAL YEAR 1979 FUNDING $307,417
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $877,082

OBJECTIVE

The purpose of this contract is twofold:

- To conduct system engineering studies to assess the technical and economic feasibility and risks for advanced central power concepts.
- To provide the technical management of the Line Focus Receiver Phase I study contracts.

APPROACH

Three tasks have been specified:

- Define and evalute repowering concepts, advanced heliostat designs, and advanced high-temperature receiver designs.
- Combine solar and geothermal power sources.
- In relation to the RFP, establish evaluation criteria, evaluate the proposals, and establish the DOE program plan.

STATUS

The contractor has assisted DOE's San Francisco Operations Office in the management of industry contracts in the field of developing large power systems by providing:

- Advanced system engineering studies, analyses, and evaluations of potential options, especially in the fields of central receiver systems, solar hybrid systems, and solar repowering/retrofit systems.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-1

CONTRACTOR/ADDRESS	TITLE
Aerospace Corporation P. O. Box 9257 Los Angeles, California 90009	Systems Engineering Studies and Program Technical Support
	CONTRACT NO. 03-79ET21060
PRINCIPAL INVESTIGATOR H. Bernstein	PERIOD OF PERFORMANCE July 3, 1979 to November 30, 1979
WORK LOCATION Los Angeles, California	FISCAL YEAR 1979 FUNDING $307,417
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $877,082

(continued)

- Technical support to DOE management of R&D contractor's performance, especially by monitoring and evaluating technical details of contractor performance, identifying problem areas, recommending possible solutions, and assisting in (1) formulation of RFP's and (2) evaluation and selection of industry proposals.
- Assistance in technical management of line-focus systems development, especially in (1) reviewing progress and providing technical guidance to contractors, (2) identifying problems and recommending changes, (3) performing systems engineering analyses, and (4) assisting in procurement activities.
- Computer simulations for the Central Receiver Test Facility, especially by integrating computer program modules, conducting simulations, and studying the simulated performance.

FUTURE EFFORT

Analysis will continue on advanced concepts.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-2

CONTRACTOR/ADDRESS	TITLE
Arizona Public Service Company P. O. Box 21666 Phoenix, Arizona 85036	Solar Repowering/Industrial Retrofit Systems
	CONTRACT NO. DE-AC03-79SF10739
PRINCIPAL INVESTIGATOR E. Weber	PERIOD OF PERFORMANCE September 24, 1979 to June 24, 1980
WORK LOCATION Phoenix, Arizona	FISCAL YEAR 1979 FUNDING $104,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $104,000

OBJECTIVE

The goal of this effort is to demonstrate the technical viability and identify the economic potential of solar repowering for commercial electrical power generation. Specifically, the project's objective is to support the development of the best site-specific conceptual design that will provide practical and effective use of solar energy for repowering an electrical power plant, have the potential for construction and operation by 1985, and make maximum use of existing solar thermal technology.

APPROACH

This study will provide a site-specific conceptual design for solar repowering of the Arizona Public Service Company's Saguaro Unit 1 facility.

STATUS

The conceptual design is presently underway. Site-specific data is being gathered and examined.

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractors: Martin Marietta Aerospace Corporation; Badger Energy, Inc.; Gibbs & Hill, Inc.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-3

CONTRACTOR/ADDRESS	TITLE
BDM Corporation McLean, Virginia c/o BDM Technology Applications Center 2600 Yale Boulevard, S.E. Albuquerque, New Mexico 87106	Line Focus Solar Thermal Central Power
	CONTRACT NO. DE-AC03-79ET20524
PRINCIPAL INVESTIGATOR M. Semmons	PERIOD OF PERFORMANCE September 29, 1978 to November 30, 1979
WORK LOCATION Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $5,914
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $488,798

OBJECTIVE

The project objective is to develop a conceptual design of a 100-MWe power plant utilizing a line-focus collecting system.

APPROACH

The BDM Corporation is preparing a conceptual design of a 100-MWe power plant which utilizes a solar parabolic trough collecting system. The design concept which has been developed, and is to be presented with diagrams and drawings for the electric power plant, utilizes a 21-foot aperture parabolic collector with a "D"-shaped glass annulus, oil-filled receiver. The system utilizes a high-temperature fluid (syltherm 800) and a low-temperature fluid (therminal 55) with associated energy storage, thermocline tanks. Two hundred and thirty MW hours of storage can be provided.

STATUS

The conceptual design is now under evaluation.

FUTURE EFFORT

The final design report for this system will be available in February 1980.

Subcontractors: Stearns-Roger Engineering Company; Public Service of New Mexico

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-4

CONTRACTOR/ADDRESS	TITLE
Bechtel National, Inc. P. O. Box 3965 50 Beale Street San Francisco, California 94119	Preliminary Heat Pipe Testing Program
	CONTRACT NO. DE-AC03-79SF10756
PRINCIPAL INVESTIGATOR Y. Lam	PERIOD OF PERFORMANCE September 11, 1979 to June 11, 1980
WORK LOCATION San Francisco, California	FISCAL YEAR 1979 FUNDING $245,119
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $245,119

OBJECTIVE

The aim of this project is to conduct heat pipe testing to obtain life and performance data in an environment simulating that proposed for a Brayton-cycle solar receiver.

APPROACH

To accomplish the objective, the following tasks are required:

- A system operation analysis to develop receiver subsystem requirements is to be conducted.
- A receiver operation analysis to define design features and operational characteristics (to be used as a basis for test planning) is to be conducted.
- Test planning and preparation for life testing and component performance testing of heat pipes are to be undertaken.
- Testing and data analysis are to be carried out.

STATUS

This program, which was just started, is a continuation of a heat pipe receiver study conducted by Dynatherm (EY-76-C-02-2839) and a hybrid system study just completed by Bechtel (DE-AC03-79ET21050).

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

CONTRACTOR/ADDRESS	TITLE
Bechtel National, Inc. P. O. Box 3965 50 Beale Street San Francisco, California 94119	Preliminary Heat Pipe Testing Program
	CONTRACT NO. DE-AC03-79SF10756
PRINCIPAL INVESTIGATOR Y. Lam	PERIOD OF PERFORMANCE September 11, 1979 to June 11, 1980
WORK LOCATION San Francisco, California	FISCAL YEAR 1979 FUNDING $245,119
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $245,119

(continued)

FUTURE EFFORT

Analysis and testing will be completed.

Subcontractors: Dynatherm Corporation; Foster Wheeler Development Corporation

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-5

CONTRACTOR/ADDRESS	TITLE
Bechtel National, Inc. P. O. Box 3965 50 Beale Street San Francisco, California 94119	Solar Central Receiver Hybrid Power System
	CONTRACT NO. DE-AC03-78ET21050 (formerly ET-78-C-03-2051)
PRINCIPAL INVESTIGATOR	PERIOD OF PERFORMANCE
Y. Lam	September 29, 1978 to November 30, 1979
WORK LOCATION	FISCAL YEAR 1979 FUNDING
San Francisco, California	$21,980
CONTRACTING OFFICE	CUMULATIVE FUNDING
San Francisco Operations Office Oakland, California	$629,234

OBJECTIVE

This contract has three objectives:

- To select, develop, and assess concepts for electrical generating plants combining solar thermal central receiver and conventional fossil-fired thermal energy sources.
- To assess market potential for the preferred design.
- To identify critical technical as well as other issues requiring resolution if development is to proceed to the commercialization stage.

APPROACH

The contractor has been required to review and analyze the Preliminary Specification provided by DOE; conduct preliminary survey and analysis of market requirements; carry out parametric analyses and tradeoffs at the component, subsystem, and system level; select the preferred overall system configuration; provide a conceptual design of the preferred commercial-scale (100 MWe, nominal) plant and cost/performance estimates; assess potential improvements, limitations, and market opportunities for the preferred plant; prepare a development plan for implementation. (A requirement for proposals for a follow-on Phase II effort was deleted in view of the opportunity offered by the Repowering/Industrial Retrofit solicitation.)

STATUS

This contract effort is near completion; a final report is to be submitted in November 1979. The selected system has 5,121 heliostats surrounding a three-cavity receiver (on the east, west, and north sides). The receiver is placed on a 475-foot tower of low-cost, tubular steel construction (derived from North Sea oil platform experience). The cavities are lined with tubes pierced by sodium and potassium-filled heat pipes (according to temperature/flux level)

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-5

CONTRACTOR/ADDRESS	TITLE
Bechtel National, Inc. P. O. Box 3965 50 Beale Street San Francisco, California 94119	Solar Central Receiver Hybrid Power System
	CONTRACT NO. DE-AC03-78ET21050 (formerly ET-78-C-03-2051)
PRINCIPAL INVESTIGATOR	PERIOD OF PERFORMANCE
Y. Lam	September 29, 1978 to November 30, 1979
WORK LOCATION	FISCAL YEAR 1979 FUNDING
San Francisco, California	$21,980
CONTRACTING OFFICE	CUMULATIVE FUNDING
San Francisco Operations Office Oakland, California	$629,234

(continued)

through which the incident solar radiation heats air, compressed to 180 psi, to 1,500 ^{o}F; high-alloy construction is employed in the receiver, ducts, and heat pipes where required for the high temperatures produced. The heated air is boosted to 2,000 ^{o}F in an oil-fired combustor to drive a gas turbine which powers both the intake compressor and a 74-MWe (net) electrical generator. Exhaust air at 1,000 ^{o}F raises steam for a 950 ^{o}F/1,000 psi turbine-generator of 39 MWe net output. Capital cost is projected to be $1,060/kWe (1979 dollars) for a heliostat cost of $80/m^2.

Subcontractors: Foster Wheeler Development Corporation; Northrup, Incorporated; Public Service of New Mexico (consultant)

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-6

CONTRACTOR/ADDRESS	TITLE
Black & Veatch Consulting Engineers Box 8405 Kansas City, Missouri 64114	Solar Repowering for Electrical P. O. Generation
	CONTRACT NO. DE-AC03-79SF10738
PRINCIPAL INVESTIGATOR L. Levy	PERIOD OF PERFORMANCE September 24, 1979 to June 24, 1980
WORK LOCATION Kansas City, Missouri	FISCAL YEAR 1979 FUNDING $113,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $113,000

OBJECTIVE

The goal of this effort is to demonstrate the technical viability and identify the economic potential of solar repowering for commercial electrical power generation. Specifically, the project objective to support the development of the best site-specific conceptual design that will provide practical and effective use of solar energy for repowering an electrical power plant, have the potential for construction and operation by 1985, and make maximum use of existing solar thermal technology.

APPROACH

This study shall provide a site-specific conceptual design for solar repowering of the Public Service Company of Oklahoma's (PSO) Northeastern Unit 1 facility.

STATUS

The conceptual design is presently underway. Site-specific data is being gathered and examined.

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractors: Babcock & Wilcox Company; Public Service Company of Oklahoma

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-7

CONTRACTOR/ADDRESS	TITLE
Boeing Engineering & Construction Co. P. O. Box 3707 Seattle, Washington 98124	Central Receiver Solar Thermal Power System
	CONTRACT NO. DE-AC03-76ET20424 (formerly EY-76-C-03-1111)
PRINCIPAL INVESTIGATOR	**PERIOD OF PERFORMANCE**
B. Gillette	June 14, 1975 to May 31, 1979
WORK LOCATION	**FISCAL YEAR 1979 FUNDING**
Seattle (Kent), Washington	$0
CONTRACTING OFFICE	**CUMULATIVE FUNDING**
San Francisco Operations Office Oakland, California	$1,425,316

OBJECTIVE

The purpose of this contract was to design and develop a collector subsystem which can be integrated with other subsystems to demonstrate the technical feasibility and potential economic feasibility of solar thermal water/steam central-receiver-type power plants.

APPROACH

The Boeing concept utilizes circular membrane reflectors, formed with aluminized polyester film, to direct sunlight to the central receiver. Transparent air-support plastic enclosures protect the lightweight reflectors from the environment. The reflectors are aimed with a two-axis gimbal and driven by digital-controlled stepper motors under computer control.

STATUS

Under this contract, the following activities have been accomplished:

- Three heliostats (1/2 scale) and a drive and control assembly have been fabricated and tested to provide design data and verification.
- An evaluation program has been conducted on the key plastic materials used for the protective enclosure reflector.
- Performance and environmental exposure tests on large-scale heliostats have been conducted over a 28-month period at a Boeing desert test site in northeast Oregon to determine optical performance, demonstrate operation of drive and control assembly in the various operational modes, and verify survivability of hardware in the environment.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-7

CONTRACTOR/ADDRESS	TITLE
Boeing Engineering & Construction Co. P. O. Box 3707 Seattle, Washington 98124	Central Receiver Solar Thermal Power System
	CONTRACT NO. DE-AC03-76ET20424 (formerly EY-76-C-03-1111)
PRINCIPAL INVESTIGATOR B. Gillette	PERIOD OF PERFORMANCE June 14, 1975 to May 31, 1979
WORK LOCATION Seattle (Kent), Washington	FISCAL YEAR 1979 FUNDING $0
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $1,425,316

(continued)

- Plastic materials evaluation tests have included measurement of mechanical and optical properties, creep, chemical exposure, cleanability, accelerated simulated sunlight, and actual desert sunshine exposure tests.

- One of the desert exposure heliostats has been transferred to Sandia Laboratories in Livermore, California, for test and evaluation; two have had the enclosures replaced with a new lower cost plastic material. Desert exposure data is being obtained under a Sandia contract.

FUTURE EFFORT

Work on this contract is complete.

Bibiography Reference No.: 4

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-8

CONTRACTOR/ADDRESS	TITLE
Boeing Engineering & Construction Co. P. O. Box 3707 Seattle, Washington 98124	Conceptual Design of Advanced Central Receiver Power Systems, Phase I
	CONTRACT NO. DE-AC03-77ET20390 (formerly EG-77-C-03-1726)
PRINCIPAL INVESTIGATOR R. Gintz	PERIOD OF PERFORMANCE September 30, 1977 to June 30, 1979
WORK LOCATION Seattle (Kent), Washington	FISCAL YEAR 1979 FUNDING $83,407
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $846,389

OBJECTIVE

This effort's objective was to evaluate candidate designs for an advanced technology terrestrial solar-electric generating system of approximately 100 MWe peak net capacity using the Brayton cycle.

APPROACH

To achieve the objective, the following activities were carried out: the Preliminary Specifications provided by DOE were reviewed and analyzed; parametric analyses of components, subsystems, and overall systems were conducted; the preferred commercial-scale (100 MWe nominal) system was selected; conceptual design of a commercial-scale plant was provided; plant cost, performance, and opportunities/barriers to commercialization were assessed; safety-related factors were evaluated; and a development plan for implementation and a proposal for Phase II were provided.

STATUS

All contract efforts have been completed, and a final report has been submitted for release through DOE's Technical Information Center and the National Technical Information Service (TIC/NTIS). The selected system uses two separate 75-MWe modules with individual closed-cycle Brayton turbine-generators operating on air at 1500 ^{o}F/500 psi, for a net output of 132 MWe. The receiver is a cylindrical cavity with four apertures atop a 650-foot tower, illuminated by 10,480 30-foot diameter enclosed heliostats in each module. Compressed air is heated in a high-alloy tubing in the receiver, and 3-hour storage is provided in heated alumina brick. First/nth plant costs are estimated at $3,129/$1,930 per kWe in 1978 dollars.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-8

CONTRACTOR/ADDRESS	TITLE
Boeing Engineering & Construction Co. P. O. Box 3707 Seattle, Washington 98124	Conceptual Design of Advanced Central Receiver Power Systems, Phase I
	CONTRACT NO. DE-AC03-77ET20390 (formerly EG-77-C-03-1726)
PRINCIPAL INVESTIGATOR R. Gintz	PERIOD OF PERFORMANCE September 30, 1977 to June 30, 1979
WORK LOCATION Seattle (Kent), Washington	FISCAL YEAR 1979 FUNDING $83,407
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $846,389

(continued)

FUTURE EFFORT

No further effort is planned.

Subcontractors: Brown-Boveri & Co.; Stone & Webster; United Technology Research Center. Consultants: Portland General Electric, Public Service of New Mexico, TVA, Tucson Gas & Electric

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

CONTRACTOR/ADDRESS	TITLE
Boeing Engineering and Construction Co. P. O. Box 3707 Seattle, Washington 98124	Solar Repowering/Industrial Retrofit Systems
	CONTRACT NO. DE-AC03-79SF10742
PRINCIPAL INVESTIGATOR D. Zimmerman	PERIOD OF PERFORMANCE September 30, 1979 to June 30, 1980
WORK LOCATION Seattle, Washington	FISCAL YEAR 1979 FUNDING $112,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $112,000

OBJECTIVE

The goal of this effort is to demonstrate the technical viability and identify the economic potential of solar repowering for commercial electrical power generation. Specifically, the project's objective is to support the development of the best site-specific conceptual design that will provide practical and effective use of solar energy for repowering an electrical power plant, have the potential for construction and operation by 1985, and make maximum use of existing solar thermal technology.

APPROACH

This study will provide a site-specific conceptual design for solar retrofit of the U. S. Gypsum Based Plant in Sweetwater, Texas.

STATUS

The conceptual design is presently underway. Site-specific data is being gathered and examined.

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractors: U. S. Gypsum Company; Institute of Gas Technology

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-10

CONTRACTOR/ADDRESS	TITLE
El Paso Electric Company P. O. Box 982 El Paso, Texas 79960	An Industry Survey of the Potential for Solar Feedwater Heating
	CONTRACT NO. DE-AC03-79ET10597
PRINCIPAL INVESTIGATOR J. Brown	PERIOD OF PERFORMANCE August 1, 1979 to May 31, 1980
WORK LOCATION El Paso, Texas	FISCAL YEAR 1979 FUNDING $106,571
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $106,571

OBJECTIVE

The aim of this project is to identify the potential for favorable economics of solar feedwater heating at site-specific utility plants.

APPROACH

The contractor is to evaluate existing economic and fuel savings analyses for solar feedwater heating based on the contractor's analysis of El Paso Electric's fossil-fueled electric power plants. This comparison will occur after a detailed cost breakdown is prepared for the El Paso Electric conceptual design for feedwater heating. A utility questionnaire will be sent to candidate utilities to identify plant sites for which solar feedwater heating is viable. The potential for favorable economics of solar feedwater heating at the identified electric power plants will be summarized.

STATUS

Existing economic models are being reviewed and a utility questionnaire is being prepared.

FUTURE EFFORT

No further efforts are planned at this time.

Subcontractor: Stone and Webster.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

CONTRACTOR/ADDRESS	TITLE
El Paso Electric Company P. O. Box 982 El Paso, Texas 79960	Solar Repowering/Industrial Retrofit Systems
	CONTRACT NO. DE-AC03-79SF10740
PRINCIPAL INVESTIGATOR J. Brown	PERIOD OF PERFORMANCE September 30, 1979 to August 31, 1980
WORK LOCATION El Paso, Texas	FISCAL YEAR 1979 FUNDING $140,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $140,000

OBJECTIVE

The goal of this effort is to demonstrate the technical viability and identify the economic potential of solar repowering for commercial electrical power generation. Specifically, the project's objective is to support the development of the best site-specific conceptual design that will provide practical and effective use of solar energy for repowering an electrical power plant, have the potential for construction and operation by 1985, and make maximum use of existing solar thermal technology.

APPROACH

This study will provide a site-specific conceptual design for solar repowering of the El Paso Electric Company's Newman Unit 1 facility.

STATUS

The conceptual design is presently underway. Site-specific data is being gathered and examined.

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractors: Westinghouse Electric Corp.; Stone and Webster.

ELEMENT: Central Receiver Systems

SUBELEMENT: Systems and Applications C-12

CONTRACTOR/ADDRESS	TITLE
Energy Foundation of Texas 4800 Calhoun Street Houston, Texas 77004	Solar Energy System Simulation and Analysis
	CONTRACT NO. DE-AC03-79SF10763
PRINCIPAL INVESTIGATOR L. L. Vant-Hull	PERIOD OF PERFORMANCE September 30, 1979 to September 29, 1980
WORK LOCATION University of Houston Houston, Texas	FISCAL YEAR 1979 FUNDING $123,723
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $123,723

OBJECTIVE

The purpose of this project is twofold:

- To develop, improve, and document mathematical simulations of various system components for a central receiver power plant.
- To establish a code center for central-receiver-related codes.

APPROACH

Subprograms on (1) the simulation of distribution and redistribution of radiation for cavity receivers, (2) the effects of blocking and shading for domed heliostats, and (3) small central receiver performance for low-, intermediate-, and high-temperature applications will be developed. In addition, improvements to existing optimization simulations will be carried out, and the code center will process and transmit codes from code developers to interested users.

STATUS

The Energy Laboratory has developed a powerful array of central receiver optical performance simulation and optimization codes. These codes are extremely versatile in capacity.

FUTURE EFFORT

Recently completed enhancements of the array of codes must be fully integrated as the last step of an essentially completed reorganization of the codes into a user compatible form. The primary effort for the current year will be the provision of appropriate users guides. Code Center work is to be continued at a modest level, which will be adequate to cover archiving and delivery, to DOE, of optical and thermal central receiver codes.

Subcontractor: University of Houston

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-13

CONTRACTOR/ADDRESS	TITLE
FMC Corporation Engineering Systems Division 328 Brokaw Road Santa Clara, California 95052	Line Focus Solar Thermal Central Receiver Research Study
	CONTRACT NO. DE-AC03-76ET20426
PRINCIPAL INVESTIGATOR D. Decanio	PERIOD OF PERFORMANCE April 29, 1976 to November 30, 1979
WORK LOCATION Santa Clara, California	FISCAL YEAR 1979 FUNDING $7,138
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $526,554

OBJECTIVE

The objective of this contract was to develop and assess the performance of a specific design of line-focus system for thermally converting solar energy into electric power; the system features a multiplicity of parabolic cylinder (i.e., trough) heliostats focused upon a linear cavity-type central receiver.

APPROACH

FMC developed a conceptual design of an electric power plant, evaluated hypothetical economics for the plant, fabricated a focusing parabolic mirror module, and conducted quantitative tests on this module.

STATUS

This study has been completed. Results of these tests are contained in a final report of the same title (DOE/ET/20426 - April 1, 1979).

FUTURE EFFORT

No further efforts are planned.

Bibliography Reference No.: 5

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-14

CONTRACTOR/ADDRESS	TITLE
Foster Wheeler Development Corp. 12 Peach Tree Hill Road Livingston, New Jersey 07039	Solar Repowering/Industrial Retrofit Systems
	CONTRACT NO. DE-AC03-79SF10606
PRINCIPAL INVESTIGATOR A. Robertson	PERIOD OF PERFORMANCE September 28, 1979 to July 30, 1980
WORK LOCATION Livingston, New Jersey	FISCAL YEAR 1979 FUNDING $109,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $109,000

OBJECTIVE

The goal of this effort is to demonstrate the technical viability and identify the economic potential of solar repowering for commercial electrical power generation. Specifically, the project's objective is to support the development of the best site-specific conceptual design that will provide practical and effective use of solar energy for repowering an electrical power plant, have the potential for construction and operation by 1985, and make maximum use of existing solar thermal technology.

APPROACH

This study will provide a site-specific conceptual design for solar retrofit of the Provident Oil Refinery near Phoenix, Arizona.

STATUS

The conceptual design is presently underway. Site-specific data is being gathered and examined.

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractors: McDonnell Douglas Astronautics Company; Provident Energy Company

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-15

CONTRACTOR/ADDRESS	TITLE
General Atomic Company P. O. Box 81608 San Diego, California 92138	Line Focus Solar Central Power Systems, Phase I (Conceptual Design)
	CONTRACT NO. DE-AC03-78SF20535
PRINCIPAL INVESTIGATOR J. Schuster	PERIOD OF PERFORMANCE September 29, 1978 to September 30, 1979
WORK LOCATION San Diego, California	FISCAL YEAR 1979 FUNDING $0
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $545,698

OBJECTIVE

The aim of this project has been to develop a conceptual design of a Line-Focus Central Power System.

APPROACH

A conceptual design study was performed on a stand-alone Line Focus Solar Central Power System based on the fixed mirror solar concentrator (FMSC) for heat collection and draw salt (a 50% molar mixture of sodium nitrate and potassium nitrate) for heat transport and storage.

STATUS

Parametric analyses were performed at the subsystem level, and models were developed that were employed in a computerized simulation to minimize the cost of electricity (COE) by adjusting system design parameters. A design was prepared and costed for a first commercial plant with a rating of 100 MWe and a storage capacity equivalent to 420 MWh of electrical generation. The resulting plant can achieve an annual capacity of 45.6¢. Scaling studies indicate reductions in the COE for increased capacity factor and increased plant rating. Assessments of the plant concept indicate it should be acceptable to utilities on the basis of technical and operational considerations, but that reductions from the first 100-MWe plant cost would be required to achieve substantial market penetration.

FUTURE EFFORT

No further activities are planned at this time.

Subcontractors: Bechtel National, Inc.; Rockwell International Corporation

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-16

CONTRACTOR/ADDRESS	TITLE
General Electric Company Corporate Research & Development P. O. Box 43 Schenectady, New York 12301	Conceptual Design of Advanced Central Receiver Power Systems, Phase I
	CONTRACT NO. DE-AC0378ET20500 (formerly ET-78-C-03-1725)
PRINCIPAL INVESTIGATOR	PERIOD OF PERFORMANCE
G. R. Fox	February 1, 1978 to August 31, 1979
WORK LOCATION	FISCAL YEAR 1979 FUNDING
Schenectady, New York	$0
CONTRACTING OFFICE	CUMULATIVE FUNDING
San Francisco Operations Office Oakland, California	$674,767

OBJECTIVE

The objective of this contract was to establish the feasibility of developing a central receiver system that would significantly reduce the cost of electricity generated from solar central receivers.

APPROACH

The system incorporated a sodium-cooled receiver, a sodium storage subsystem, and a Rankine-cycle turbine.

STATUS

Contract efforts are complete. A final report was published June 1979.

FUTURE EFFORT

Further efforts are currently being funded under contract No. DE-AC03-79SF10535, Alternate Central Receiver Power Systems, Phase II.

Subcontractors: Energy Foundation of Texas; Foster Wheeler Development Corporation; Kaiser Engineers, Inc.; (other GE Departments)

Bibliography Reference No.: 6

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-17

CONTRACTOR/ADDRESS	TITLE
General Electric Company Energy System Programs Dept. Schenectady, New York 12301	Alternate Central Receiver Power System, Phase II
	CONTRACT NO. DE-AC03-79SF10535
PRINCIPAL INVESTIGATOR J. A. Elsner	PERIOD OF PERFORMANCE April 9, 1979 to March 8, 1980
WORK LOCATION Schenectady, New York Sunnyvale, California	FISCAL YEAR 1979 FUNDING $1,970,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $3,541,440

OBJECTIVE

This project has a twofold purpose:

- To refine the conceptual design of the Commercial Plant as described in Phase I.
- To conduct subsystem research experiments (SRE's) in order to provide specific technological answers relating to the use of sodium as a heat exchange fluid in a solar receiver.

APPROACH

A sodium receiver loop consisting of the receiver, pump, sump, and heat exchanger is to be designed, fabricated, and tested at Sandia's Central Receiver Test Facility (CRTF) in Albuquerque, New Mexico. Additionally, receiver fabrication techniques and processes are to be developed and a materials test program is to be conducted to provide structural and metallurgical data for the design of solar power systems.

STATUS

The commercial design refinement is virtually complete. The receiver fabrication study is complete and design of the receiver SRE is in its final stage. Fabrication of the loop has begun. Projected date of arrival at the CRTF is July 1980.

FUTURE EFFORT

The receiver will be tested and evaluated at the CRTF. The materials test program will continue.

Subcontractors: Foster Wheeler Development Corporation; Kaiser Engineers, Inc.;

Bibliography Reference No.: 6

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-18

CONTRACTOR/ADDRESS	TITLE
General Electric Company One River Road Schenectady, New York 12345	Southwestern Public Service Company Solar Repowering
	CONTRACT NO. DE-AC03-79SF10741
PRINCIPAL INVESTIGATOR J. A. Elsner	PERIOD OF PERFORMANCE September 28, 1979 to June 27, 1980
WORK LOCATION Schenectady, New York	FISCAL YEAR 1979 FUNDING $139,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $139,000

OBJECTIVE

The objective of this study is to develop a site-specific conceptual design that (1) provides practical and effective use of solar energy for repowering of electric power plants, (2) has the potential for construction and operation by 1985, (3) makes maximum use of existing solar thermal technology, and (4) provides the best possible economics for the overall plant application.

APPROACH

This design study will provide a site-specific conceptual design for solar repowering of the Southwestern Public Service Company Plant X Unit No. 3, located near Earth, Texas. The system utilizes a liquid metal-cooled central receiver to repower a 100-MWe gas-fired reheat plant, with the solar system designed to generate 60-MWe gross electric output.

The study will provide DOE, potential users, equipment manufacturers, and the public with (1) the definition of a possible solar repowering system design, component characteristics, and estimates of system performance; (2) preliminary estimates of the potential technical and economic benefits of solar repowering; (3) an indication of the solar repowering market for the application studies; (4) preliminary estimates of costs and schedules for potential subsequent solar repowering construction projects; and (5) an indication of the potential for utility and industry cost-sharing arrangements with DOE for subsequent solar repowering construction projects.

STATUS

This conceptual design effort has just begun. Site-specific data is being gathered and examined.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

CONTRACTOR/ADDRESS	TITLE
General Electric Company One River Road Schenectady, New York 12345	Southwestern Public Service Company Solar Repowering
	CONTRACT NO. DE-AC03-79SF10741
PRINCIPAL INVESTIGATOR J. A. Elsner	PERIOD OF PERFORMANCE September 28, 1979 to June 27, 1980
WORK LOCATION Schenectady, New York	FISCAL YEAR 1979 FUNDING $139,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $139,000

(continued)

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractors: Southwestern Public Service Company; Kaisers Engineers, Inc.

Bibliography Reference No.: 7

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-19

CONTRACTOR/ADDRESS	TITLE
Martin Marietta Aerospace Corp. Denver Division P. O. Box 179 Denver, Colorado 80201	Conceptual Design of Advanced Central Receiver Power Systems, Phase I
	CONTRACT NO. DE-AC03-77ET20314 (formerly EG-77-C-03-1724)
PRINCIPAL INVESTIGATOR R. Tracey	PERIOD OF PERFORMANCE September 29,1977 to October 31, 1978
WORK LOCATION Denver, Colorado	FISCAL YEAR 1979 FUNDING $19,343
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $655,204

OBJECTIVE

The aim of this effort has been to conduct systems analyses and develop conceptual designs for advanced central receiver power systems.

APPROACH

The Martin Marietta advanced central receiver concept uses a molten nitrate salt to transfer the energy from the receiver to the storage and steam generator components.

A nine-module, 300-MWe power plant has been selected as the baseline design. The design utilizes a surrounding field of heliostats working into a four-tank thermocline in which energy is stored as sensible heat in the molten salt. Pressure from the tower head is isolated from the storage system.

STATUS

Contract efforts are complete. A final report was published September 1978.

FUTURE EFFORT

Further efforts are being funded under contract No. DE-AC03-79SF10534, Alternate Central Receiver Power System, Phase II.

Subcontractors: Arizona Public Service Company; Badger Plants, Inc.; Black & Veatch Consulting Engineers

Bibliography Reference No.: 6

ELEMENT: Central Receiver Applications

SUB-ELEMENT: Systems and Applications

C-20

CONTRACTOR/ADDRESS	TITLE
Martin Marietta Aerospace Corp. Denver Division P. O. Box 179 Denver, Colorado 80201	Alternate Central Receiver Power System, Phase II
	CONTRACT NO. DE-AC03-79SF10534
PRINCIPAL INVESTIGATOR T. R. Tracy	PERIOD OF PERFORMANCE April 6, 1979 to April 5, 1981
WORK LOCATION Denver, Colorado	FISCAL YEAR 1979 FUNDING $1,888,868
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $2,857,711

OBJECTIVE

The project's aim is to refine the conceptual design of the commercial plant as described in Phase I and to conduct the subsystem research experiments (SRE's) in order to provide specific technological answers relating to the use of molten salt as a heat exchange fluid in a solar receiver.

APPROACH

A molten salt receiver loop consisting of the receiver, pump, sump, and heat exchanger will be designed, fabricated, and tested at Sandia's Central Receiver Test Facility (CRTF) in Albuquerque, New Mexico. In addition, a materials test program will be conducted to (1) demonstrate the compatibility of construction materials with molten salt and (2) demonstrate the stability of molten salt under anticipated operating conditions.

STATUS

The receiver loop is well along in design, and fabrication is beginning. The projected arrival date at the CRTF is May 1980. Long-term materials tests have begun. The molten salt loop is in checkout phases. Refinement of the commercial design continues.

FUTURE EFFORT

The receiver will be tested and evaluated at the CRTF. The materials test program will be continued.

Subcontractors: Arizona Public Service Co.; Badger Energy, Inc.; (other Martin Marietta Div.)

Bibliography Reference No.: 6

ELEMENT: Central ReceiverSystems

SUB-ELEMENT: Systems and Applications C-21

CONTRACTOR/ADDRESS	TITLE
Martin Marietta Aerospace Corp. Denver Division P. O. Box 179 Denver, Colorado 80201	Central Receiver Solar Thermal Power System Heliostat Field Wind-Effects Test
	CONTRACT NO. DE-AC03-76ET20422 (formerly EY-76-C-03-1110)
PRINCIPAL INVESTIGATOR D. N. Gorman	PERIOD OF PERFORMANCE July 1, 1978 to October 30, 1978
WORK LOCATION Denver, Colorado Ft. Collins, Colorado	FISCAL YEAR 1979 FUNDING $0
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $65,223

OBJECTIVE

The contract objective was to determine the effects of wind on a heliostat field with and without fences around the perimeter.

APPROACH

Two areas of a heliostat field were modeled to a 1:80 scale and installed in the environmental wind tunnel at Colorado State University. Flow visualization, velocity probes, and strain gauges were used to determine wind effects within the field.

STATUS

Work on this contract is complete. Results of the study indicate that fences can be used to reduce wind loads on the outer 1.6 rows of heliostats, but effects such as channeling and flow recombination will raise the inner heliostat loads to within a few percent of the values obtained in a free-stream environment.

FUTURE EFFORT

No further activities are planned at present.

Subcontractor: Colorado State University, Department of Civil Engineering

Bibliography Reference No.: 8

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

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CONTRACTOR/ADDRESS	TITLE
Martin Marietta Aerospace Corp. Denver Division P. O. Box 179 Denver, Colorado 80201	Central Receiver Solar Thermal Systems: Testing of Subsystem Research Experiment Receiver at Central Receiver Test Facility, Phase II
	CONTRACT NO. DE-AC03-76ET20422 (formerly EY-76-C-03-1110)
PRINCIPAL INVESTIGATOR D. N. Gorman	PERIOD OF PERFORMANCE July 5, 1978 to March 31, 1980
WORK LOCATION Denver, Colorado Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $0
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $509,049

OBJECTIVE

The goal of this effort is to obtain performance data (and verify previous artificial illumination test results) on the 5-MWt recirculating-flow cavity receiver in the solar environment at the Sandia Central Receiver Test Facility (CRTF). This receiver configuration provides (1) a backup alternative to the externally illuminated, once-through design selected for the Barstow 10-MWe pilot plant and (2) a possible vehicle for evaluation of advanced water-steam receiver concepts presently under study.

APPROACH

Modifications are to be made to the test receiver to adapt it to operation at the CRTF, including a cooled spillage shield surrounding the aperture, motorized cavity door, remotely operated valving, an additional attemperator, and necessary structural interfaces.

STATUS

Initial test planning has been completed. The cavity receiver is currently (as of September 1979) in safe storage near the CRTF. Except for minor, short lead-time fittings, it is ready to be installed, checked out, and tested.

FUTURE EFFORT

Subject to program requirements and funding availability, the cavity receiver will be tested following completion of the Barstow panel tests. Future use or disposition of the receiver is subject to programmatic decisions now pending on the objectives cited above. The contractor is on standby status through the 2nd quarter, FY 1980.

Subcontractor: Foster Wheeler Development Corporation

Bibliography Reference No.: 9

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-23

CONTRACTOR/ADDRESS	TITLE
Martin Marietta Aerospace Corp. Denver Division P. O. Box 179 Denver, Colorado 80201	Solar Central Receiver Hybrid Power System
	CONTRACT NO. DE-AC03-78ET21038 (formerly ET-78-C-03-2234)
PRINCIPAL INVESTIGATOR C. N. Bolton	PERIOD OF PERFORMANCE September 29, 1978 to September 30, 1979
WORK LOCATION Denver, Colorado	FISCAL YEAR 1979 FUNDING $3,484
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $633,484

OBJECTIVE

This project has had a threefold purpose:

- To select, develop, and assess concepts for electrical generating plants combining solar thermal central receiver and conventional fossil-fired thermal energy sources.
- To assess market potential for the preferred design.
- To identify critical technical and other issues requiring resolution if development is to proceed to the commercialization stage.

APPROACH

This project required the following tasks:

- Review and analyze the preliminary specification provided by DOE.
- Conduct preliminary survey and analysis of market requirements.
- Carry out parametric analyses and tradeoffs at the component, subsystem, and system level.
- Select the preferred overall system configuration.
- Provide a conceptual design of the preferred commercial scale (100 MWe, nominal) plant and cost/performance estimates.
- Assess potential improvements, limitations, and market opportunities for the preferred plant.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

CONTRACTOR/ADDRESS	TITLE
Martin Marietta Aerospace Corp. Denver Division P. O. Box 179 Denver, Colorado 80201	Solar Central Receiver Hybrid Power System
	CONTRACT NO. DE-AC03-78ET21038 (formerly ET-78-C-03-2234)
PRINCIPAL INVESTIGATOR C. N. Bolton	**PERIOD OF PERFORMANCE** September 29, 1978 to September 30, 1979
WORK LOCATION Denver, Colorado	**FISCAL YEAR 1979 FUNDING** $3,484
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	**CUMULATIVE FUNDING** $633,484

(continued)

- o Prepare a development plan for implementation.

(A requirement for proposals for a follow-on Phase II effort was deleted, in view of the opportunity offered by the Repowering/Industrial Retrofit solicitation.)

STATUS

This contract effort is complete. A final report has been submitted for release through the DOE Technical Information Center and the National Technical Information Service (TIC/NTIS). The selected system consists of 12 modules for 500-MWe net output and 18-hour storage for the solar system, parallelled with a 50% capacity oil-fired heater; the reference 100-MWe system uses two, slightly larger modules, with 12,500 heliostats surrounding a four-cavity receiver on a 514-foot tower. Molten draw salt is heated to 1050 ^{o}F in vertical, high-alloy tubing in the receiver; it is combined with salt from the fossil heater and held in the hot tank(s) of a hot/cold tank storage system, from which it is drawn to raise steam for a 1000 ^{o}F/1800 psi reheat turbine generator. First-plant capital cost at 100 MWe is projected at $1,924/kWe (1979 dollars), with heliostats at $72/m^2; 500 MWe costs are lower by about 15%.

Subcontractors: Arizona Public Service Company; Badger Plants, Inc.; Foster Wheeler Development Corporation; Gibbs & Hill, Inc.

Bibliography Reference No.: 10

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-24

CONTRACTOR/ADDRESS	TITLE
Martin Marietta Aerospace Corp. P. O. Box 179 Denver, Colorado 80201	Solar Repowering/Industrial Retrofit Systems
	CONTRACT NO. DE-AC03-79SF10737
PRINCIPAL INVESTIGATOR D. Gorman	PERIOD OF PERFORMANCE September 28, 1979 to June 28, 1980
WORK LOCATION Denver, Colorado	FISCAL YEAR 1979 FUNDING $134,000 (incremental funding)
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $134,000

OBJECTIVE

The goal of this effort is to demonstrate the technical viability and identify the economic potential of solar repowering for industrial process heat.

APPROACH

The contractor shall develop a conceptual design for a central receiver solar thermal power system to displace the combustion of crude oil for the generation of steam used for thermal enchanced oil recovery (EOR) operations in Exxon's Edison field near Bakersfield, California. The solar energy conversion process being proposed is based on sound, proven technology and presents virtually no risk to the implementation of an operational system by 1985. Total cost estimates and economic analyses will be performed; they will include modification costs of existing plant equipment, site preparation, and operating factors including down time.

STATUS

The conceptual design is presently underway. Site-specific data is being gathered and examined.

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractors: Exxon Corporation; Foster Wheeler Development Corp.; Black & Veatch Consulting Engineers

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-25

CONTRACTOR/ADDRESS McDonnell Douglas Astronautics 5301 Bolsa Avenue Huntington Beach, California 94612	**TITLE** Central Receiver Solar Thermal Power Systems: Modification of Receiver Subsystem Research Experiment for Testing at Central Receiver Test Facility
	CONTRACT NO. DE-AC03-76ET20417 (formerly EY-76-C-03-1108)
PRINCIPAL INVESTIGATOR G. C. Coleman	**PERIOD OF PERFORMANCE** • March 14, 1978 to February 1, 1980
WORK LOCATION Huntington Beach, California Canoga Park, California Albuquerque, New Mexico	**FISCAL YEAR 1979 FUNDING** $793,177
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	**CUMULATIVE FUNDING** $8,888,514

OBJECTIVE

The project objective is twofold:

- To obtain comprehensive data on performance, response to transient conditions, and operational procedures for a representative single panel of the Barstow 10-MWe pilot plant external, once-through-to-superheat receiver over the anticipated range of solar flux levels.
- To assess potential performance of a larger, commercial-scale receiver at higher flux levels.

APPROACH

The McDonnell Douglas 5-MWt Subsystem Research Experiment (SRE) test panel (previously tested under artificial illumination) is to be modified for testing in the solar environment at Sandia's Central Receiver Test Facility (CRTF); modifications include addition of instrumentation, remotely operated valving and controls, refractory insulation protection against flux spillage, movable insulation to reduce effective length of panel to current value for pilot plant, orificing or receiver tubing as needed to maintain flow stability, interfaces to CRTF facilities, and support structure. The test assembly is to be delivered to CRTF and prepared for installation. A test overview is to be provided.

STATUS

Responsibility for installation, checkout, and testing of the 5-MWe panel at the CRTF was assumed at the beginning of the 3rd quarter, FY 1979 by Sandia Laboratories at Livermore, California, (SLL Contract #83-4746), and the equivalent scope was deleted from this contract. The panel has been successfully tested to 80% of pilot plant flux, operational control strategies have been developed, and control of flow instabilities under flux gradients and transients by orificing has been demonstrated.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-25

CONTRACTOR/ADDRESS	TITLE Central Receiver Solar Thermal Power Systems: Modification of Receiver Subsystem Research Experiment for Testing at Central Receiver Test Facility
McDonnell Douglas Astronautics 5301 Bolsa Avenue Huntington Beach, California 94612	CONTRACT NO. DE-AC03-76ET20417 (formerly EY-76-C-03-1108)
PRINCIPAL INVESTIGATOR G. C. Coleman	PERIOD OF PERFORMANCE March 14, 1978 to February 1, 1980
WORK LOCATION Huntington Beach - Canoga Park, California Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $793,177
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $8,888,514

(continued)

Flux redirectors are currently (September 1979) being installed flanking the panel to permit testing at commercial-scale plant flux levels (2nd quarter, FY 1980).

FUTURE EFFORT

The overview test effort is scheduled to resume between November 1979 and January 1980; accountability for the project hardware and equipment is to be maintained.

Subcontractors: Rocketdyne Division, Rockwell International Corporation; Los Angeles Division, Rockwell International Corporation (2nd tier sub to Rocketdyne)

Bibliography Reference No.: 11

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-26

CONTRACTOR/ADDRESS	TITLE
McDonnell Douglas Astronautics Co. 5301 Bolsa Avenue Huntington Beach, California 92647	Gulf Mt. Taylor Uranium Mill Solar Retrofit
	CONTRACT NO. DE-AC03-79SF10608
PRINCIPAL INVESTIGATOR L. W. Glover	PERIOD OF PERFORMANCE September 24, 1979 to June 23, 1980
WORK LOCATION Huntington Beach, California	FISCAL YEAR 1979 FUNDING $193,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $193,000

OBJECTIVE

The objective of this study is to develop a site-specific conceptual design that (1) provides practical and effective use of solar energy for industrial retrofit for process heat plants, (2) has the potential for construction and operation by 1985, (3) makes maximum use of existing solar thermal technology, and (4) provides the best possible economics for the overall plant application.

APPROACH

This design study will provide a site-specific conceptual design for solar industrial retrofit for process heat at the Gulf Mt. Taylor Uranium Mill near San Mateo, New Mexico. The concept utilizes a water/steam central receiver designed to provide a maximum of 36% of the mill energy requirements during summer and an average of 23% over the year.

This study will provide DOE, potential users, equipment manufacturers, and the public with (1) the definition of a possible solar industrial retrofit system design, component characteristics, and estimates of system performance; (2) preliminary estimates of the potential technical and economic benefits of solar industrial retrofit; (3) an indication of the solar industrial retrofit market for the application studied; (4) preliminary estimates of costs and schedules for potential subsequent solar industrial retrofit construction projects; and (5) an indication of the potential for utility and industry cost-sharing arrangements with DOE for subsequent solar industrial retrofit construction projects.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-26

CONTRACTOR/ADDRESS	TITLE
McDonnell Douglas Astronautics Co. 5301 Bolsa Avenue Huntington Beach, California 92647	Gulf Mt. Taylor Uranium Mill Solar Retrofit
	CONTRACT NO. DE-AC03-79SF10608
PRINCIPAL INVESTIGATOR L. W. Glover	PERIOD OF PERFORMANCE September 24, 1979 to June 23, 1980
WORK LOCATION Huntington Beach, California	FISCAL YEAR 1979 FUNDING $193,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $193,000

(continued)

STATUS

This conceptual design effort began in September 1979. Site-specific data is being gathered and examined.

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractors: Gulf Research & Development Company; University of Houston; Foster Wheeler Development Corporation

ELEMENT: Central Receiver Applications

SUB-ELEMENT: Systems and Applications

C-27

CONTRACTOR/ADDRESS	TITLE
McDonnell Douglas Astronautics Co. 5301 Bolsa Avenue Huntington Beach, California 94612	Solar Repowering/Industrial Retrofit Systems
	CONTRACT NO. DE-AC03-79SF10609
PRINCIPAL INVESTIGATOR B. Easton	PERIOD OF PERFORMANCE September 24, 1979 to June 23, 1980
WORK LOCATION Huntington Beach, California	FISCAL YEAR 1979 FUNDING $196,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $196,000

OBJECTIVE

The aim of this contract is to demonstrate the technical viability and identify the economic potential of solar repowering for commercial electrical power generation. The project objective is to support the development of the best site-specific conceptual design that will provide practical and effective use of solar energy for repowering an electrical power plant, have the potential for construction and operation by 1985, and make maximum use of existing solar thermal technology.

APPROACH

This study will provide a site-specific conceptual design for solar retrofit of the Sierra Pacific Power Fort Churchill Unit 1.

STATUS

The conceptual design is presently underway. Site-specific data is being gathered and examined.

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractors: University of Houston; Foster Wheeler Development Corporation; Westinghouse; Stearns-Roger Engineering Company; Desert Research Institute; Sierra Pacific Power Company

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-28

CONTRACTOR/ADDRESS	TITLE
Northrup, Inc. 302 Nichols Drive Hutchins, Texas 75141	Solar Industrial Retrofit System
	CONTRACT NO. DE-AC03-79SF10736
PRINCIPAL INVESTIGATOR R. Henry	PERIOD OF PERFORMANCE September 15, 1979 to June 14, 1980
WORK LOCATION Hutchins, Texas	FISCAL YEAR 1979 FUNDING $91,000 (incremental funding)
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $91,000

OBJECTIVE

The goal of this effort is to demonstrate the technical viability and identify the economic potential of solar repowering for industrial process heat.

APPROACH

This study shall produce a site-specific conceptual design consisting of heliostat modules and receivers with integral manifolding, using solar energy to produce process heat. The solar system is to be installed adjacent to the Arco North Coles Levee Plant No. 8, located 22 miles west of Bakersfield, California. The conceptual design of the solar system and existing plant interface will be defined in sufficient detail to permit establishment of reliable performance and design construction cost estimates.

STATUS

The conceptual design is presently underway. Site-specific data is being collected and examined.

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractor: Arco Oil and Gas Company

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-29

CONTRACTOR/ADDRESS	TITLE
PFR Engineering Systems, Inc. 7676 Admiralty Way, Suite 832 Marina Del Ray, California 90291	Valley Nitrogen Producers Ammonia Plant Solar Retrofit
	CONTRACT NO. DE-AC03-79SF10735
PRINCIPAL INVESTIGATOR T. Rosenman	PERIOD OF PERFORMANCE September 30, 1979 to June 30, 1980
WORK LOCATION Marina Del Ray, California	FISCAL YEAR 1979 FUNDING $100,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $100,000

OBJECTIVE

The objective of this study is to develop a site-specific conceptual design that (1) provides practical and effective use of solar energy for industrial retrofit for process heat plants, (2) has the potential for construction and operation by 1985, (3) makes maximum use of existing solar thermal technology, and (4) provides the best possible economics for the overall plant applications.

APPROACH

This design study will provide a site-specific conceptual design for solar industrial retrofit for the Valley Nitrogen Producers, Inc. (El Centro) ammonia plant located in Helm, California. The system utilizes catalyst-filled tubes in a solar central receiver cavity designed to provide 125 MW Btu/hour or almost the entire heat load of the reforming plant.

The study will provide DOE, potential users, equipment manufacturers, and the public with (1) the definition of a possible solar industrial retrofit system design, component characteristics, and estimates of system performance; (2) preliminary estimates of the potential technical and economic benefits of solar industrial retrofit; (3) an indication of the solar industrial retrofit market for the application studied; (4) preliminary estimates of costs and schedules for potential subsequent solar industrial retrofit construction projects; and (5) an indication of the potential for utility and industry cost-sharing arrangements with DOE for subsequent solar industrial retrofit construction projects.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-29

CONTRACTOR/ADDRESS	TITLE
PFR Engineering Systems, Inc. 7676 Admiralty Way, Suite 832 Marina Del Ray, California 90291	Valley Nitrogen Producers Ammonia Plant Solar Retrofit
	CONTRACT NO. DE-AC03-79SF10735
PRINCIPAL INVESTIGATOR T. Rosenman	PERIOD OF PERFORMANCE September 30, 1979 to June 30, 1980
WORK LOCATION Marina Del Ray, California	FISCAL YEAR 1979 FUNDING $100,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $100,000

(continued)

STATUS

The conceptual design effort began in September 1979. Site-specific data is being collected and examined.

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractor: Valley Nitrogen Producers, Inc.; McDonnell Douglas Astronautics Company

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

CONTRACTOR/ADDRESS	TITLE
Rockwell International Corporation Energy Systems Group (formerly Atomics International) 8900 De Soto Avenue Canoga Park, California 91304	Conceptual Design of Advanced Central Receiver Power Systems
	CONTRACT NO. DE-AC03-77ET20393 (formerly EG-77-C-03-1483)
PRINCIPAL INVESTIGATOR	**PERIOD OF PERFORMANCE**
T. H. Springer	September 30, 1977 to August 31, 1979
WORK LOCATION	**FISCAL YEAR 1979 FUNDING**
Canoga Park, California	$37,575
CONTRACTING OFFICE	**CUMULATIVE FUNDING**
San Francisco Operations Office Oakland, California	$655,125

OBJECTIVE

The project's aim was to select and develop a conceptual design for an advanced central receiver power system that will significantly reduce the cost of electricity generated by solar thermal means.

APPROACH

The following tasks were required:

- Review and analyze the Preliminary Specifications provided by DOE.
- Conduct parametric analyses of components and subsystems.
- Select the preferred commercial-scale (100 MWe, nominal) system.
- Provide a conceptual design of a commercial-scale plant.
- Assess plant cost, performance, and opportunities/barriers to commercialization.
- Evaluate plant safety factors.
- Provide a development plan for implementation and proposal for phase II.

STATUS

All contract effort is complete, and a final report was submitted for release through DOE's Technical Information Center and the National Technical Information Service (TIC/NTIS). The selected system is a single-module plant of 281 MWe net capacity, with a 24-panel, vertical tube, externally illuminated receiver atop a 550-foot tower near the center of the field.

ELEMENT: Central Receiver Systems

SUBELEMENT: Systems and Applications

C-30

CONTRACTOR/ADDRESS	TITLE
Rockwell International Corporation Energy Systems Group (formerly Atomics International) 8900 De Soto Avenue Canoga Park, California 91304	Conceptual Design of Advanced Central Receiver Power Systems
	CONTRACT NO. DE-AC03-77ET20393 (formerly EG-77-C-03-1483)
PRINCIPAL INVESTIGATOR T. H. Springer	PERIOD OF PERFORMANCE September 30, 1977 to August 31, 1979
WORK LOCATION Canoga Park, California	FISCAL YEAR 1979 FUNDING $37,575
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $655,125

(continued)

Sodium, mechanically pumped through the high-alloy receiver and heated to 1100 ^{o}F, is used as the heat transport fluid. In-line "hot" and "cold" storage tanks of 3-hour capacity decouple the receiver circuit from a heat-exchanger train in which steam at 1000 ^{o}F and 1800-2400 psi is raised for a reheat-cycle turbine-generator set. (Heat exchange between the sodium and a large air-rock storage unit could permit near-baseload operation.) Scaled to 100 MWe, first/nth plant costs (in 1978 dollars) are estimated at $1,526/$1,237 per kWe.

FUTURE EFFORT

No further effort is planned under this contract. The possibility of DOE testing and evaluation of a privately funded sodium receiver panel at the Central Receiver Test Facility is, however, under discussion.

Subcontractors: McDonnell Douglas Astronautics Company; Stearns-Roger Engineering Company; University of Houston (2nd tier, to MDAC); Salt River Project (Utility Consultant)

Bibliography Reference No.: 12

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-31

CONTRACTOR/ADDRESS	TITLE
Rockwell International Corporation Energy Systems Group 8900 De Soto Avenue Canoga Park, California 91304	Solar Central Receiver Hybrid Power System CONTRACT NO. DE-AC03-78ET20567 (formerly ET-78-C-03-2233)
PRINCIPAL INVESTIGATOR T. H. Springer	PERIOD OF PERFORMANCE September 29, 1977 to December 31, 1979
WORK LOCATION Canoga Park, California	FISCAL YEAR 1979 FUNDING $0
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $633,915

OBJECTIVE

The project goal is threefold:

- To select, develop, and assess concepts for electrical generating plants combining solar thermal central receiver and conventional fossil-fired thermal energy sources.
- To assess market potential for the preferred design.
- To identify critical technical and other issues requiring resolution if development is to proceed to the commercialization stage.

APPROACH

The contractor has been required to review and analyze the preliminary specification provided by DOE; conduct preliminary survey and analysis of market requirements; carry out parametric analyses and tradeoffs at the component, subsystem, and system level; select the preferred overall system configuration; provide a conceptual design of the preferred commercial-scale (100 MWe, nominal) plant and cost/performance estimates; assess potential improvements, limitations, and market opportunities for the preferred plant; and prepare a development plant for implementation. (A requirement for proposals for a follow-on Phase II effort was deleted, in view of the opportunity offered by the Repowering/Industrial Retrofit solicitation.)

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-31

CONTRACTOR/ADDRESS	TITLE
Rockwell International Corporation Energy Systems Group 8900 De Soto Avenue Canoga Park, California 91304	Solar Central Receiver Hybrid Power System
	CONTRACT NO. DE-AC03-78ET20567 (formerly ET-78-C-03-2233)
PRINCIPAL INVESTIGATOR T. H. Springer	PERIOD OF PERFORMANCE September 29, 1977 to December 31, 1979
WORK LOCATION Canoga Park, California	FISCAL YEAR 1979 FUNDING $0
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $633,915

(continued)

STATUS

The task effort has been completed; a final report submission has been deferred (by agreement) to December 1979. The preferred plant has a single solar module in parallel with an oil-fired heater and 3-hour in-line storage, supplying 430 MWe; 61,000 heliostats surround a vertical-tube, externally illuminated receiver on a 1,050-foot tower. At 100 MWe, the preferred configuration consists of a solar module of 80% capacity, a coal-fired heater (providing 20-100% capacity), in-line buffer storage (10-20 minutes) with a hot tank on the receiver tower, 8,500 heliostats, and a 385-foot tower. Liquid sodium is the heat transfer/storage fluid, heated to 1,100 ^{o}F in high-alloy receiver tubes. Steam is raised in Liquid Metal Fast Breeder Reactor (LMFBR)-technology heat exchangers to supply the 1,000 ^{o}F/2,400 psi (430 MWe) or 1,800 psi (100 MWe) turbine-generators. First-plant capital cost, at 100 MWe and with $94/m^2 heliostats, is projected at $1,605/kWe (1979 dollars).

FUTURE EFFORT

Beyond completion of the final report, no further effort is contemplated.

Subcontractors: Babcock & Wilcox; McDonnell Douglas Astronautics Company; Salt River Project; SRI International; Stearns-Roger Engineering Company; University of Houston (2nd tier sub to MDAC)

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications C-32

CONTRACTOR/ADDRESS	TITLE
Rockwell International Corporation Energy Systems Group 8900 De Soto Avenue Canoga Park, California 91304	Texas Electric Service Company Solar Repowering
	CONTRACT NO. DE-AC03-79ET10607
PRINCIPAL INVESTIGATOR T. H. Springer	PERIOD OF PERFORMANCE September 13, 1979 to June 12, 1980
WORK LOCATION Canoga Park, California	FISCAL YEAR 1979 FUNDING $84,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $84,000

OBJECTIVE

The objective of this study is to develop a site-specific conceptual design that (1) provides practical and effective use of solar energy for repowering of electric power plants, (2) has the potential for construction and operation by 1985, (3) makes maximum use of existing solar thermal technology, and (4) provides the best possible economics for the overall plant application.

APPROACH

This design study will provide a site-specific conceptual design for solar repowering of the Texas Electric Service Company Permian Basin Station Unit 5, located near Monahans, Texas. Specific conceptual designs and economic assessments will be prepared for a sodium-cooled central receiver to repower a 115-MWe gas-fired reheat plant, with the solar system designed to generate 60-MWe gross electric output.

The study will provide DOE, potential users, equipment manufacturers, and the public with (1) the definition of a possible solar repowering system design, component characteristics, and estimates of system performance; (2) preliminary estimates of the potential technical and economic benefits of solar repowering; (3) an indication of the solar market for the application studied; (4) preliminary estimates of costs and schedules for potential subsequent solar repowering construction projects; and (5) an indication for subsequent solar repowering construction projects.

STATUS

This conceptual design effort has just begun. Site-specific data is being gathered and examined.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-32

CONTRACTOR/ADDRESS	TITLE
Rockwell International Corporation Energy Systems Group 8900 De Soto Avenue Canoga Park, California 91304	Texas Electric Service Company Solar Repowering
	CONTRACT NO. DE-AC03-79ET10607
PRINCIPAL INVESTIGATOR T. H. Springer	**PERIOD OF PERFORMANCE** September 13, 1979 to June 12, 1980
WORK LOCATION Canoga Park, California	**FISCAL YEAR 1979 FUNDING** $84,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	**CUMULATIVE FUNDING** $84,000

(continued)

FUTURE EFFORT

This project may be eligible for a definitive design award.

Subcontractors: Texas Electric Service Company; McDonnell Douglas Astronautics Company; Stearns-Roger Engineering Company; University of Houston

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

CONTRACTOR/ADDRESS	TITLE
SRI International 333 Revenswood Avenue Menlo Park, California 94025	Analysis of Mesoscale Weather and Climate Changes Caused by Large Solar Electric Power Plants and Their Effects on Plant Performance
	CONTRACT NO. DE-AC03-78SF20535 (formerly EY-76-C-03-1115/PA0143)
PRINCIPAL INVESTIGATOR	PERIOD OF PERFORMANCE
C. M. Bhumralkar	September 29, 1979 to January 31, 1980
WORK LOCATION	FISCAL YEAR 1979 FUNDING
Menlo Park, California	$0
CONTRACTING OFFICE	CUMULATIVE FUNDING
San Francisco Operations Office Oakland, California	$86,683

OBJECTIVE

The basic objectives of the contract are:

- To use an existing two-dimensional mesoscale atmospheric model to determine whether there are any significant atmospheric effects of large solar thermal electric plants on local and regional (mesoscale) weather.
- To determine the effects of changes in weather, if any, caused by solar thermal power plants on the performance of the plant itself.

APPROACH

A two-dimensional grid (distance along wind vector through plant; normalized height above terrain), with variable spacing to emphasize the vicinity of the plant is to be constructed. In addition, an SRI-developed climatological model is to be applied to compare distributions of humidity, temperature, wind velocity, and other parameters in the presence of a "typical" central receiver solar power plant with those that would be obtained in its absence. If significant differences are found, their effects (cloud cover, wet-dry bulb temperature, winds, etc.) on plant performance are to be assessed. The terrain, climatology, and plant configuration representative of a 100-MWe-scale plant at the Barstow pilot plant site is to be utilized as a reference baseline.

STATUS

Preliminary runs of 9-hour duration have been made for both "without" and "with" power plant scenarios. The results are being analyzed and examined to determine their quantitative realism. Work is somewhat behind schedule due to delayed completion of a prior project for another agency.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

C-34

CONTRACTOR/ADDRESS	TITLE
SRI International 333 Ravenswood Avenue Menlo Park, California 94025	Line Focus Solar Center Power Systems, Phase I (Conceptual Design)
	CONTRACT NO. DE-AC03-78ET20550
PRINCIPAL INVESTIGATOR A. Slemons	PERIOD OF PERFORMANCE September 29, 1978 to September 30, 1979
WORK LOCATION Menlo Park, California	FISCAL YEAR 1979 FUNDING $0
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $571,132

OBJECTIVE

The purpose of this effort is to develop a conceptual design of a 100-MWe power plant utilizing a line-focus collector system.

APPROACH

SRI International is preparing a conceptual design of a 100-MWe electric power plant which utilizes tower-mounted linear cavity heat receivers. The solar energy is placed in the cavity by nonfocusing linear parabolic mirrors which track the sun in one axis only. There are ten rows of receivers mounted on 200-foot towers and associated 24 rows of north field heliostats. The receiver cooling fluid is salt which is also the energy storage medium. Storage is provided for 7.5 hours at 100 MW. The total field area for the plant is 657 acres.

STATUS

The conceptual design is now under evaluation.

FUTURE EFFORT

Future activities, if any, will be determined upon review of output of present work. The draft final report for this system should be available in January 1980.

Subcontractors: Bechtel National, Inc.;Foster Wheeler Development Corporation; Pacific Gas and Electric Company; Acurex Corporation

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Systems and Applications

CONTRACTOR/ADDRESS	TITLE
U. S. Bureau of Reclamation (705) Lower Colorado Regional Office P. O. Box 427 Boulder City, Nevada 89005	Solar Thermal Electric Plants in a Hydroelectric Grid
	CONTRACT NO. DE-AI03-79SF10505 (Interagency Cooperative Agreement)
PRINCIPAL INVESTIGATOR J. Kitchen	**PERIOD OF PERFORMANCE** February 1, 1979 to January 31, 1980
WORK LOCATION Boulder City, Nevada Denver, Colorado	**FISCAL YEAR 1979 FUNDING** $100,000
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	**CUMULATIVE FUNDING** $100,000

OBJECTIVE

The project purpose is to evaluate the costs and benefits of integration of solar central receiver power plants into the Bureau of Reclamation hydroelectric grid.

APPROACH

Lower Colorado River Region hydroelectric insolation and solar central receiver performance and cost data is to be accumulated.

Potential solar plant sites are to be selected on the basis of insolation, and water and land availability (effects on agriculture, wilderness areas, forests, endangered species, etc.). In addition, historical hydrologic and insolation data and anticipated solar plant output are to be analyzed to determine the cost and quality of firm power which can be marketed within the constraints of irrigation demand and weather outages.

STATUS

The study is 70% complete, with potential solar sites near Yuma, Arizona, and Morman Mesa, Nevada, having been chosen. The necessary hydrologic, insolation, performance, and cost data is in hand and the analysis is about 50% complete; initial results show a firm power resource at competitive prices.

FUTURE EFFORT

This study is scheduled to be completed by February 1980.

Subcontractors: USBR Engineering & Research Center, Denver Federal Center

ELEMENT: Central Receiver Systems

SUBELEMENT: Systems and Applications C-36

CONTRACTOR/ADDRESS	TITLE
Westinghouse Electric Corporation Advanced Systems Technology East Pittsburgh, Pennsylvania 15112	Economic Assessment of Advanced Solar Thermal Plants
	CONTRACT NO. DE-AC03-79SF10601
PRINCIPAL INVESTIGATOR T. Day	PERIOD OF PERFORMANCE June 15, 1979 to March 15, 1980
WORK LOCATION East Pittsburgh, Pennsylvania	FISCAL YEAR 1979 FUNDING $129,800
CONTRACTING OFFICE San Francisco Operations Office Oakland, California	CUMULATIVE FUNDING $221,321

OBJECTIVE

The objectives of this study are to provide an economic assessment of advanced solar thermal power systems and to evaluate the economic impact upon specific electric utility systems having a variety of solar thermal power plant concepts and configurations in a central station electric generating system role.

APPROACH

The economic value and impact of a number of solar thermal alternatives will be evaluated in such a manner as to provide a consistent comparison of a number of concepts under development and to determine preferred configurations. The economic assessment will be from a microeconomic aspect, without consideration of factors such as national balance-of-payment or employment effects. Because of uncertainty in a number of economic parameters, a range of assumptions will be used.

STATUS

A number of concepts and configurations have been selected and are now undergoing assessment.

FUTURE EFFORT

Other design evaluations of interest to DOE have been proposed.

CENTRAL RECEIVER SYSTEMS

D. Subsystems and Components Project Summaries

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-1

CONTRACTOR/ADDRESS	TITLE
Argonne National Laboratory 9700 S. Cass Avenue Argonne, Illinois 60439	Materials Testing for Central Receiver Systems
	CONTRACT NO. 92-7648
PRINCIPAL INVESTIGATOR S. Majumdar and W. J. Shack	PERIOD OF PERFORMANCE June 1977 to October 1979
WORK LOCATION Argonne, Illinois	FISCAL YEAR 1979 FUNDING $273,127
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $494,000

OBJECTIVE

This project has had three aims:

- To provide mechanical properties data on specified candidate materials for application in central receivers.
- To evaluate material specimens for creep-fatigue in a simulated solar environment at elevated temperature with biaxial cyclic loading plus compressive hold times.
- To survey literature for effects of sodium environment on candidate materials.

APPROACH

Tubular specimens at 1100 ^{o}F were subjected to internal pressure plus axial cyclic loading with compressive hold times.

STATUS

All tests have been completed and a final report is due. Additionally, a survey has been completed and a corresponding report is due.

FUTURE EFFORT

No further activities are anticipated.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-2

CONTRACTOR/ADDRESS	TITLE
Babcock and Wilcox 1562 Beeson Alliance, Ohio 44601	Receiver Design
	CONTRACT NO. 18-6879 A
PRINCIPAL INVESTIGATOR P. Parikh	PERIOD OF PERFORMANCE March 12, 1979 to November 30, 1979
WORK LOCATION Barberton, Ohio	FISCAL YEAR 1979 FUNDING $541,944
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $541,944

OBJECTIVE

The contract purpose is to conceptually design an advanced water/steam receiver.

APPROACH

An assumed baseline design is being modified and optimized by parametric analyses. A conceptual design for a 100-MWe commercial receiver will be defined.

STATUS

This project is 75% complete.

FUTURE EFFORT

Future activities are to be determined; a receiver test at CRTF is being considered for one of the three advanced water/steam receivers.

Subcontractor: Black & Veatch

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-3

CONTRACTOR/ADDRESS	TITLE
Battelle Pacific Northwest Laboratories Battelle Boulevard Richland, Washington 99352	Development of Mirror Specifications
	CONTRACT NO. EY-76-C-06-1830 (92-8165)
PRINCIPAL INVESTIGATOR M. A. Lind	PERIOD OF PERFORMANCE February 1, 1979 to September 30, 1979
WORK LOCATION Richland, Washington	FISCAL YEAR 1979 FUNDING $162,671
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $162,671

OBJECTIVE

The primary objective was to develop specifications that will enhance the durability and lifetime of heliostat mirrors. In addition, technical and measurement support was required for evaluation of the Barstow pilot plant heliostat glass and updating of the glass specifications developed in FY 1978.

APPROACH

The contract was initiated with a technical survey of the present commercial silvered glass mirror industry and an analytical investigation of the degradation phenomena experienced by the heliostat mirrors at Sandia's Livermore test facility. The main thrust was to evaluate the present methods of silver deposition and protection in order to recommend a specification for the heliostat mirror silvering process that would extend the lifetime of the Barstow mirror field. In addition, several advanced concepts for enhancing mirror lifetime were investigated.

STATUS

The survey of the mirror silvering industry has been completed and recommendations for a mirror specification have been prepared. Experimental and analytical data has been collected to help define and control mirror degradation. The pilot plant heliostat glass has been evaluated for compliance with requirements. A draft of the final report has been prepared.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-3

CONTRACTOR/ADDRESS	TITLE
Battelle Pacific Northwest Laboratories Battelle Boulevard Richland, Washington 99352	Development of Mirror Specifications
	CONTRACT NO. EY-76-C-06-1830 (92-8165)
PRINCIPAL INVESTIGATOR M. A. Lind	PERIOD OF PERFORMANCE February 1, 1979 to September 30, 1979
WORK LOCATION Richland, Washington	FISCAL YEAR 1979 FUNDING $162,671
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $162,671

(continued)

FUTURE EFFORT

Continuation of the mirror degradation study, development of improved mirrors, and further refinement of the mirror specification are planned.

Bibliography Reference No.: 13

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-4

CONTRACTOR/ADDRESS	TITLE
Beckman Instruments, Inc. 1630 South State College Blvd. Anaheim, California 92816	Portable Absolute Reflectometer
	CONTRACT NO. 83-0385
PRINCIPAL INVESTIGATOR R. A. Weigant	PERIOD OF PERFORMANCE October 6, 1978 to March 31, 1979
WORK LOCATION Anaheim, California	FISCAL YEAR 1979 FUNDING $167,250
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $167,250

OBJECTIVE

The aim of this project is to design, fabricate, test, and deliver two portable hand-held prototype absolute reflectometers to assess mirror reflectance or plastic film degradation as a consequence of weathering.

APPROACH

This instrument shall utilize the "V-W" geometric technique to measure the absolute reflectance of the test mirrors. The geometry change from a "V" configuration to a "W" configuration must be accomplished using the same areas on the internal mirrors with no change in the angle of incidence. Since this principle inherently measures the square of the test mirror reflectance, means were provided for taking the square root and displaying the reflectance.

STATUS

Two reflectometers have been delivered and evaluated. The contract objectives were satisfied.

FUTURE EFFORT

No further activities are planned.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-5

CONTRACTOR/ADDRESS	TITLE
Boeing Engineering & Construction Co. P. O. Box 3707 Seattle, Washington 98124	One-Piece Dome Fabrication Study
	CONTRACT NO. SLL 18-7830
PRINCIPAL INVESTIGATOR R. B. Gillette	PERIOD OF PERFORMANCE August 1978 to July 1979
WORK LOCATION Seattle, Washington	FISCAL YEAR 1979 FUNDING $360,000
CONTRACTING OFFICE Sandia Laboratory Livermore, California	CUMULATIVE FUNDING $414,135

OBJECTIVE

The goal of this effort was to investigate thermoforming techniques that will allow the forming of a dome from a single piece of relatively thick material.

APPROACH

To obtain the desired-size domes from reasonable-size starting sheets, a high area extension ratio was required. To evaluate capability of a film for extension, a relationship between time, temperature, pressure, and extension ratio was developed for all candidate materials. Other techniques that reduced the extension requirements or increased strength were investigated. These included laminations, staging or preforming, and joints that would not interfere with the thermoforming. Candidate materials slated for evaluation included oriented and non-oriented polyesters, cellulose acetate butyral, and polyvinylidene fluoride (Kynar). The latter material (Kynar) was evaluated by Pennwalt Corporation under a subcontract following a compatible schedule. Discussions were held with plastics manufacturers early in the effort to yield additional candidates.

STATUS

Test domes were fabricated from the Petra AXB, Melinex O, Meliform, and PETG 7821. These included domes with heat-sealed joints and laminated butt joints. Forming experiments were also performed, with limited success, on Dupont Tadlar 150 TRF and 150 TRMF, Chemplast Halar, and Eastman Cellulose Acetate Butyrate. Kynar has been selected for primary emphasis due to its superior weatherability. Kynar domes of up to approximately 4-1/2 feet in diameter have been formed.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-5

CONTRACTOR/ADDRESS	TITLE
Boeing Engineering & Construction Co. P. O. Box 3707 Seattle, Washington 98124	One-Piece Dome Fabrication Study
	CONTRACT NO. SLL 18-7830
PRINCIPAL INVESTIGATOR R. B. Gillette	PERIOD OF PERFORMANCE August 1978 to July 1979
WORK LOCATION Seattle, Washington	FISCAL YEAR 1979 FUNDING $360,000
CONTRACTING OFFICE Sandia Laboratory Livermore, California	CUMULATIVE FUNDING $414,135

(continued)

FUTURE EFFORT

Due to funding limitations, no future effort is planned.

Subcontractor: Pennwalt Corporation

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

CONTRACTOR/ADDRESS	TITLE
Boeing Engineering & Construction Co. P. O. Box 3707 Seattle, Washington 98124	Plastic Film Performance Improvement
	CONTRACT NO. 83-0035 D
PRINCIPAL INVESTIGATOR R. B. Gillette	PERIOD OF PERFORMANCE April 9, 1979 to April 9, 1980
WORK LOCATION Seattle, Washington	FISCAL YEAR 1979 FUNDING $82,775
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $82,775

OBJECTIVE

The purpose of this contract is to develop and test improved enclosure and reflector plastic films. This will be achieved by the joint effort of the contractor and industrial film supplier. The major activities include film supplier interfacing; outdoor exposure testing; laboratory testing; design, process, and cost updating; and progress reporting.

APPROACH

Upon screening and passing the mechanical and optical property requirements, a candidate will be prepared for outdoor exposure testing. Small coupons will be cut and attached to test racks at the Desert Sunshine Exposure Test (DSET) Facility. Real-time exposure testing on south-facing, 45° elevation racks and accelerated testing on eight-sun equatorial mount with mirrors for acceleration (EMMA's) will be performed. Subsequent to outdoor exposure, samples will be retested for degradation in mechanical properties.

STATUS

Boeing has contacted 30 suppliers of plastic films and reflectors, and has had 19 active responses. Materials submitted have been evaluated for transmittance, reflectance, and mechanical properties; 15 different materials/coatings have been set-up in Arizona for desert exposure tests. Real-time and accelerated exposure tests are being run.

FUTURE EFFORT

Any follow-up materials experimentation will depend on the results obtained from these studies.

Subcontractor: Desert Sunshine Exposure Test (DSET) Facility

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-7

CONTRACTOR/ADDRESS	TITLE
Boeing Engineering and Construction Co. P. O. Box 3707 Seattle, Washington 98124	2nd Generation Heliostat Development
	CONTRACT NO. 83-2729C
PRINCIPAL INVESTIGATOR R. B. Gillette	PERIOD OF PERFORMANCE August 28, 1979 to February 29, 1981
WORK LOCATION Seattle, Washington	FISCAL YEAR 1979 FUNDING $250,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $1,655,207

OBJECTIVE

The contract objective is to provide a high-performance, low life-cycle cost heliostat design that can be volume-produced at rates of 25,000 to 50,000 per year with an assumed 30-year plant lifetime. Designs and costs should address manufacturing, assembly, installation, and maintenance approaches and should be made available to the solar community. Stimulation of broader industry participation in the DOE solar energy program is also an objective.

APPROACH

Boeing is the leader of a team which will design, test, and plan the production heliostats. Ford Aerospace will design and build the gimbal actuator for the single linear actuator elevation drive design, while Pittsburgh-Corning will fabricate the fusion/foam glass/float glass mirror modules.

STATUS

At the program kickoff meeting (September 25, 1979) the baseline design and intended tradeoffs were presented. A management plan and limited test plan have been submitted. A preliminary design review is scheduled for January 1980 and a final design review will occur in March 1981.

FUTURE EFFORT

The detailed design report is to be completed by June 1980. The prototype heliostat delivery for testing is scheduled for September 1980. A final report is to be delivered by February 1981.

Subcontractors: Ford Aerospace; Pittsburgh-Corning

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-8

CONTRACTOR/ADDRESS	TITLE
Combustion Engineering Inc. 1000 Prospect Hill Road Windsor, Connecticut 06095	Advanced Water/Steam Receiver Conceptual Design
	CONTRACT NO. 18-6879 B
PRINCIPAL INVESTIGATOR H. Payne	PERIOD OF PERFORMANCE January 8, 1979 to December 31, 1979
WORK LOCATION Windsor, Connecticut	FISCAL YEAR 1979 FUNDING $404,500
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $404,500

OBJECTIVE

The objective of the advanced water/steam program is to develop on a conceptual design basis a water/steam boiler which is more cost effective than those proposed for the 10MWe Barstow pilot plant. The procurement was divided into two categories. Advanced receivers (Category II) were defined as those with steam at pressure or temperature above those of the Barstow plant (10.5 MPa or 516 ^{o}C); the contractor was the successful offeror on Category II; although considered "advanced," the concept was to be capable of demonstration in the mid to late 1980's. Storage, heliostats, and other subsystem evaluations were not to constitute a significant effort in this program.

APPROACH

Parametric analysis of steam cycles and turbines indicate the necessity of employing reheat turbines. To perform reheat functions, storage, solar, and live steam reheat are to be evaluated parametrically. Experimentally, single-side heating on rifled and smooth bore tubes are to be performed to determine critical heat flux as a function of flow rate and pressure.

STATUS

Due to hardware procurement and delivery delays, a 3-month no-cost extension has been requested and granted. Parametric studies to date show that careful integration of storage, electric power, generating, and receiver subsystems is required. Three subcritical receiver flows and one supercritical receiver loop are being optimized against various turbines and storage capacities.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-8

CONTRACTOR/ADDRESS	TITLE
Combustion Engineering Inc. 1000 Prospect Hill Road Windsor, Connecticut 06095	Advanced Water/Steam Receiver Conceptual Design
	CONTRACT NO. 18-6879 B
PRINCIPAL INVESTIGATOR H. Payne	PERIOD OF PERFORMANCE January 8, 1979 to December 31, 1979
WORK LOCATION Windsor, Connecticut	FISCAL YEAR 1979 FUNDING $404,500
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $404,500

(continued)

FUTURE EFFORT

Experimental tasks are to be completed; the conceptual design is to be finalized and documented. The rescheduled completion date is December 31, 1979.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-9

CONTRACTOR/ADDRESS	TITLE
Combustion Engineering, Inc. 1000 Prospect Hill Road Windsor, Connecticut 06095	Receivers
	CONTRACT NO. 18-2557
PRINCIPAL INVESTIGATOR C. Bozzuto	PERIOD OF PERFORMANCE October 31, 1977 to September 30, 1980
WORK LOCATION Windsor, Connecticut	FISCAL YEAR 1979 FUNDING $93,743
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $184,990

OBJECTIVE

The contract purpose is to provide independent analysis of the McDonnell Douglas Astronautics Corporation/Central Receiver Test Facility and Sandia 5-Tube Test data for relevance to the Barstow pilot plant receiver design.

APPROACH

The test data with analysis and boiler industry design standards are being compared. Analysis techniques are being updated and modified so as to provide additional design capabilities for Barstow and future water/steam receivers.

STATUS

Data analysis is partially complete.

FUTURE EFFORT

Activities will continue through FY 1980 until all significant data has been analyzed.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-10

CONTRACTOR/ADDRESS	TITLE
Energy Foundation of Texas 4800 Calhoun Boulevard Houston, Texas 77004	Analysis of Extreme Winds on Solar Tower Generators
	CONTRACT NO. EG-77-C-04-3974 77-TT-1 Subtask B
PRINCIPAL INVESTIGATOR J. H. Strickland	PERIOD OF PERFORMANCE September 1979 to August 1980
WORK LOCATION Texas Tech University Lubbock, Texas	FISCAL YEAR 1979 FUNDING $112,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $112,000

OBJECTIVE

The aim of the project is to experimentally determine the vortex shedding frequencies of a single heliostat.

APPROACH

Tests will be conducted in a blower tunnel facility with 1/22-scale model heliostats. The effects of various free-steam conditions and heliostat attitudes on vortex shedding frequencies will be observed using an autocorrelated two-channel hot wire anemometer.

STATUS

The tunnel facility is complete with the exception of some signal conditioning equipment.

FUTURE EFFORT

Data concerning natural vortex shedding frequencies and mean flow fields for a model heliostat will be generated and analyzed.

Subcontractor: Texas Tech University

ELEMENT: Central Receiver Systemss

SUB-ELEMENT: Subsystem and Components

D-

CONTRACTOR/ADDRESS	TITLE
Fluor Pioneer 200 West Monroe Chicago, Illinois 60606	Cost Analyst Services
	CONTRACT NO. 18-9376
PRINCIPAL INVESTIGATOR R. Morrow	PERIOD OF PERFORMANCE November 1978 to September 30, 1979
WORK LOCATION Sandia Laboratories Livermore, California	FISCAL YEAR 1979 FUNDING $125,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $125,000

OBJECTIVE

The goal of this contract is to analyze solar central receiver contractor cost estimates and normalize them to a common basis.

APPROACH

Contractor cost estimates will be reviewed and analyzed.

STATUS

The first cost analyst has returned to Fluor. Sandia is currently negotiating the services of a second analyst.

FUTURE EFFORT

The second cost analyst will review hybrid, water/steam, and other cost estimates to determine consistency of the estimating basis.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-12

CONTRACTOR/ADDRESS	TITLE
Foster-Miller Associates, Inc. 350 Second Avenue Waltham, Massachusetts 02154	Automatic Heliostat Cleaning System
	CONTRACT NO. 83-00351
PRINCIPAL INVESTIGATOR P. Tremblay	PERIOD OF PERFORMANCE April 5, 1979 to May 31, 1980
WORK LOCATION Waltham, Massachusetts	FISCAL YEAR 1979 FUNDING $149,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $149,000

OBJECTIVE

The objective of this effort is to provide an in-depth evaluation of the requirments for the heliostat cleaning and optimal development of a system to meet these requirements.

APPROACH

A three-phase program is proposed leading to the demonstration of a prototype heliostat cleaning module. Phase I will develop a detailed specification of heliostat cleaning requirements with particular emphasis on costs and benefits as a function of cleaning effectiveness and frequency. A conceptual system design is to be developed to meet these requirements. In Phase II, a detailed system design will be prepared and critical system components will be defined, evaluated, and tested. In Phase III, a module of the cleaning system will be fabricated and tested. The system design will then be refined based on the outcome of the test program.

The cleaning system is composed of a heliostat-mounted water spray system which traverses the surface of the heliostat from top to bottom. Spray nozzles are attached to a header which rides in guides attached to the sides of the heliostat. Flexible hoses are used to pipe deionized water from the high-pressure supply. Most of the water can be collected and returned for reprocessing.

STATUS

A preliminary design has been developed based on experimental tests for water pressure and spray nozzle configuration. Initial cost estimates have been made which indicate that the concept, with further design improvement, will be cost effective.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

CONTRACTOR/ADDRESS	TITLE
Foster-Miller Associates, Inc. 350 Second Avenue Waltham, Massachusetts 02154	Automatic Heliostat Cleaning System
	CONTRACT NO. 83-00351
PRINCIPAL INVESTIGATOR P. Tremblay	PERIOD OF PERFORMANCE April 5, 1979 to May 31, 1980
WORK LOCATION Waltham, Massachusetts	FISCAL YEAR 1979 FUNDING $149,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $149,000

(continued)

FUTURE EFFORT

The detailed design is to be completed by November 1979 and prototype fabrication and testing is to be finished by January 1980. A final report will be issued in March 1980.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-13

CONTRACTOR/ADDRESS	TITLE
Foster Wheeler Development Corp. 12 Peach Tree Hill Road Livingston, New Jersey 07039	Interim Structural Design Standard for Solar Energy Applications
	CONTRACT NO. 87-9151
PRINCIPAL INVESTIGATOR A. C. Gangadharan	PERIOD OF PERFORMANCE May 1977 to December 31, 1979
WORK LOCATION Livingston, New Jersey	FISCAL YEAR 1979 FUNDING $83,779
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $162,500

OBJECTIVE

The objectives of this project are to investigate the applicability of the present American Society of Mechanical Engineers (ASME) Boiler Code to solar energy systems, particularly receivers; to develop an applicable interim structural design standard; and to evaluate test results and correlate them analytically.

APPROACH

The ASME Boiler Code is to be reviewed for areas which do not adequately address solar applications; those portions which will be applicable are to be specified. Modified design rules for use on solar systems, as well as areas needing specific study, are to be identified.

STATUS

The interim standard has been completed. Analysis of test results is still underway.

FUTURE EFFORT

Correlation of test results will be completed. Work on rules for advanced solar systems using other working fluids is desirable.

Bibliography Reference No.: 14

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

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CONTRACTOR/ADDRESS	TITLE
General Atomic Corporation P. O. Box 81608 San Diego, California 92117	Corrosion Fatigue
	CONTRACT NO. 13-2618
PRINCIPAL INVESTIGATOR J. Kaae	PERIOD OF PERFORMANCE September 22, 1979 to September 30, 1980
WORK LOCATION San Diego, California	FISCAL YEAR 1979 FUNDING $73,900
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $73,900

OBJECTIVE

The purpose of this effort is to conduct material testing of 1,800 tube samples to determine the susceptibility of these samples to combined corrosion fatigue in boiling water and superheated steam environments.

APPROACH

Unique tube samples are to be tested with conventional material testing techniques.

STATUS

Initial screening-type tests are complete. Additional testing with long compressive hold times are underway.

FUTURE EFFORT

Tests of molten salt as well as water/steam will be continued through FY 1980.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-15

CONTRACTOR/ADDRESS	TITLE
General Electric Company 1 River Road Schenectady, New York 12345	Electric Power Generation System (EPGS) Study
	CONTRACT NO. 83-7550
PRINCIPAL INVESTIGATOR G. Oganowski	PERIOD OF PERFORMANCE June 29, 1979 to December 31, 1979
WORK LOCATION Schenectady, New York	FISCAL YEAR 1979 FUNDING $70,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $70,000

OBJECTIVE

The project aim is to define possible unique combinations of receiver and thermal storage steam conditions which can be utilized by existing steam turbines in support of the Advanced Water/Steam Receiver Program.

APPROACH

General Electric is analyzing conventional steam turbines in the size ranges of 50 to 250 MWe, both reheat and non-reheat for pressure ranges of 1,500 to 2,400 psi. In addition, the necessary steam conditions from thermal storage to produce 70% to 90% of nameplate rating for each of the turbine cycles during operation from storage is to be defined. This information will be used by Sandia and others in defining optimum thermal storage systems for water/steam receivers.

STATUS

This study is 70% complete.

FUTURE EFFORT

No activities are planned after contract completion.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components 16

CONTRACTOR/ADDRESS	TITLE
General Electric Company 1 River Road Schenectady, New York 12345	Heliostat Materials Development and Evaluation Program
	CONTRACT NO. 83-0024B
PRINCIPAL INVESTIGATOR F. N. Mazandarany	PERIOD OF PERFORMANCE February 1979 to April 1980
WORK LOCATION Schenectady, New York	FISCAL YEAR 1979 FUNDING $250,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $250,000

OBJECTIVE

The program has the overall objective of establishing a firm data base for prediction of useful life cycles and performance of enclosed heliostat materials.

APPROACH

Samples of polyester polyvinylidene fluoride (PVDF) and three selected reflector materials are to be exposed to ultraviolet light for increasing increment of dosage, followed by optical and physical property measurements. Optical measurements will be reflectance, transmittance, and specularity, as appropriate. Physical properties to be measured are tensile and creep for reflector materials as well as tensile, creep, tear resistance, and mar resistance for the PVDF enclosure material. These samples will be compared to outdoor samples exposed to 1, 4, 8, and 16 suns.

STATUS

Biaxially oriented Kynar film has been successfully made under this contract. Pennwalt Corporation and Marshall & Williams Company assisted with fabrication of the film. Reflectors and several film bonding samples have also been made and the 12 months of desert exposure has started.

FUTURE EFFORT

Follow-on efforts will be determined by the outcome of the testing and correlation predictions.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-17

CONTRACTOR/ADDRESS	TITLE
General Electric Company 310 DeGuigne Drive Sunnyvale, California 94086	Pilot Plant Receiver
	CONTRACT NO. 18-2969
PRINCIPAL INVESTIGATOR	PERIOD OF PERFORMANCE
S. Wolfe	August 9, 1978 to September 30, 1980
WORK LOCATION	FISCAL YEAR 1979 FUNDING
Sunnyvale, California	$96,494
CONTRACTING OFFICE	CUMULATIVE FUNDING
Sandia Laboratories Livermore, California	$188,205

OBJECTIVE

The goal of this study is to provide independent analysis of McDonnell Douglas Astronautics Corporation/Central Receiver Test Facility and Sandia 5-Tube Test data for relevance to the Barstow pilot plant receiver design.

APPROACH

The test data is to be compared with analysis. Analysis techniques are to be updated and modified so as to provide additional design capabilities for Barstow and future water/steam receivers.

STATUS

Data analysis is partially complete.

FUTURE EFFORT

Activities are scheduled to continue through FY 1980 until all significant data has been analyzed.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-18

CONTRACTOR/ADDRESS	TITLE
General Electric Company 1 River Road Schenectady, New York 12345	Review IEA Project
	CONTRACT NO. 83-8069
PRINCIPAL INVESTIGATOR R. Salemme	PERIOD OF PERFORMANCE June 27, 1979 to November 30, 1979
WORK LOCATION Schenectady, New York	FISCAL YEAR 1979 FUNDING $50,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $50,000

OBJECTIVE

This project has had a twofold purpose:

- To provide an independent assessment of the International Energy Agency (IEA) sodium central receiver.
- To assess what benefits can be gained from the IEA plant which will be applicable to American sodium central receivers.

APPROACH

The IEA design was compared with General Electric's conceptual design for American sodium central receivers.

STATUS

This contract has been completed.

FUTURE EFFORT

No further activities are planned.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-19

CONTRACTOR/ADDRESS	TITLE
General Electric Company Energy Systems & Tech. Division 310 DeGuigne Drive Sunnyvale, California 94086	Design Feedwater System
	CONTRACT NO. PO #83-2776
PRINCIPAL INVESTIGATOR D. Eldred	PERIOD OF PERFORMANCE September 18, 1978 to April 30, 1979
WORK LOCATION San Jose, California	FISCAL YEAR 1979 FUNDING $73,798
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $73,798

OBJECTIVE

This contract has had a dual objective:

- To design and fabricate a feedwater system and a water chemistry monitor station for use in the 5-Tube Departure from Nucleate Boiling Test.
- To assist with the 5-Tube Test start up until the General Electric (GE) provided systems operate satisfactorily.

APPROACH

A Sandia-Livermore/GE design team integrated the specific needs of the 5-Tube Test into the hardware design; GE then proceeded with the detail design.

STATUS

The feedwater system and water chemistry monitor station were delivered in March 1979. The contract is now complete.

FUTURE EFFORT

No further activities are planned.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-20

CONTRACTOR/ADDRESS	TITLE
General Electric Company Space Division Valley Forge Space Center P. O. Box 8555 Philadelphia, Pennsylvania 19101	Molded Plastic Heliostat Reflective Panels
	CONTRACT NO. 83-0035B
PRINCIPAL INVESTIGATOR R. Hobbs	PERIOD OF PERFORMANCE August 1979 to May 1980
WORK LOCATION Valley Forge, Pennsylvania	FISCAL YEAR 1979 FUNDING $144,500
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $144,500

OBJECTIVE

The project objective is to develop a low-cost, high-strength, lightweight heliostat reflector panel based on moldable epoxy compounds suitable for use with conventional transfer molding techniques in high-volume mass production.

APPROACH

A preliminary design phase, to include panel design, material and component testing, mold design, and production cost and performance estimates, will be followed by a detailed design iteration. One mold and 400 square feet of prototype panels will then be fabricated and evaluated; results will be documented in a final report.

STATUS

Efforts were started in early August 1979. The work is slightly behind schedule due to some personnel changes at General Electric.

FUTURE EFFORT

Work is expected to continue as outlined. Four hundred square feet of reflector panels are to be delivered to Sandia-Livermore at the end of the contract.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-21

CONTRACTOR/ADDRESS	TITLE
Honeywell, Inc. Energy Resources Center 2600 Ridgeway Parkway Minneapolis, Minnesota 55413	Honeywell Latent Heat Thermal Storage Subsystem Research Experiment
	CONTRACT NO. PR# 18-8426
PRINCIPAL INVESTIGATOR R. LeFrois	PERIOD OF PERFORMANCE August 7, 1978 to October 1979
WORK LOCATION Minneapolis, Minnesota	FISCAL YEAR 1979 FUNDING $173,033
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $173,033

OBJECTIVE

The aim of this project was to collect a quantitative set of experimental data to evaluate a particular design concept for storage of thermal energy vs. heat of fusion in salts. Potential applications included (1) storage of excess thermal energy during off-peak hours of electric utility plants for the purpose of providing energy to meet later peak requirements and (2) storing thermal energy at solar thermal power stations.

APPROACH

Honeywell was to provide labor, materials, and facilities to design, construct, test, and evaluate a 1.3-MWt-hour molten salt thermal storage subsystem research experiment. In order to provide good heat transfer during the energy retrieval step, the Honeywell concept utilizes rotary tube scrapers for removing frozen salt from heat exchange surfaces.

STATUS

Work under the present contract was cancelled because of test site and funding priority problems.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-22

CONTRACTOR/ADDRESS	TITLE
University of Illinois Dept. of Mechanical & Industrial Engineering Urbana, Illinois 61801	Experimental Study of Convective Losses from Solar Receivers
	CONTRACT NO. 87-9180
PRINCIPAL INVESTIGATOR A. M. Clausing	PERIOD OF PERFORMANCE October 22, 1979 to September 30, 1980
WORK LOCATION Urbana, Illinois	FISCAL YEAR 1979 FUNDING $104,815
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $159,815

OBJECTIVE

The aim of this project is to support receiver design by establishing convective losses of both external and cavity receivers for various wind vectors.

APPROACH

To determine losses, three tasks are required:

- Establish techniques by which the combined influences of natural and forced convection on the convective heat loss can be modeled and experimentally studied.
- Design and build a cryogenic facility for the experimental investigation.
- Test models of solar receivers and obtain expressions which enable the prediction of the convective loss.

STATUS

A cryogenic wind tunnel has been fabricated and tests are presently underway to establish its validity for determining convective losses from full-scale central receivers by measurements made on small-scale receiver models. A successful validation program for both overall and local heat transfer is needed before the tunnel can be used with confidence to predict the performance of full-scale receivers.

FUTURE EFFORT

After validation is completed, attention will be focused on developing a detailed understanding of the combined forced and natural convective losses from representative receiver geometries. If validation requirements are not satisfied in FY 1980, the program will be terminated.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-23

CONTRACTOR/ADDRESS	TITLE
Martin Marietta Aerospace Corporation Denver Division P. O. Box 179 Denver, Colorado 80201	Advanced Water/Steam Receiver Design
	CONTRACT NO. 18-6879 C
PRINCIPAL INVESTIGATOR D. Gorman	PERIOD OF PERFORMANCE January 5, 1979 to December 31, 1979
WORK LOCATION Denver, Colorado	FISCAL YEAR 1979 FUNDING $499,486
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $499,486

OBJECTIVE

The purpose of this project is to design a cost-effective water/steam receiver system.

APPROACH

To meet the objective, the contractor is to minimize cost of steam-turbine quality energy at the base of the tower.

STATUS

Final technical review was scheduled to occur on October 4, 1979.

FUTURE EFFORT

No further activities are anticipated.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-

CONTRACTOR/ADDRESS	TITLE
Martin Marietta Aerospace Corporation Denver Division P. O. Box 179 Denver, Colorado 80201	2nd Generation Heliostat Development for Solar Central Receiver
	CONTRACT NO. 83-2729B
PRINCIPAL INVESTIGATOR L. Oldham	PERIOD OF PERFORMANCE July 16, 1979 to February 28, 1981
WORK LOCATION Denver, Colorado	FISCAL YEAR 1979 FUNDING $200,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $200,000

OBJECTIVE

One of the project objectives is to provide a high-performing, low life-cycle cost heliostat design that can be volume-produced at rates of 25,000-50,000 per year with an assumed 30-year plant lifetime. Designs and costs should address manufacturing, assembly, installation, and maintenance approaches and should be made available to the solar community. Stimulation of broader industry participation in the DOE solar energy program is also an objective.

APPROACH

The approach taken by Martin Marietta is to substantially change the baseline from the Phase I concept. Design features include laminated glass edge-mounted mirrors, a single motor two-axis drive system with brakes, a pile-driven pedestal/foundation assembly, battery emergency stow power, and fiber optic communication between each heliostat control and the heliostat field control.

STATUS

At the program kickoff meeting on September 19, 1979, the baseline design and intended tradeoffs were presented. A management plan and limited test plan have been submitted.

FUTURE EFFORT

A preliminary design review is scheduled for February 1980 and a final design review is scheduled for April 1980. After a design is selected, two heliostats will be produced and tested at Sandia's Central Receiver Test Facility in Albuquerque, New Mexico. A manufacturing plant will be designed and costs for the various phases will be provided.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-25

CONTRACTOR/ADDRESS	TITLE
Martin Marietta Aerospace Corporation Denver Division P. O. Box 179 Denver, Colorado 80201	Salt Experiment
	CONTRACT NO. PO #83-3638
PRINCIPAL INVESTIGATOR T. R. Heaton	PERIOD OF PERFORMANCE October 1, 1979 to September 30, 1979
WORK LOCATION Denver, Colorado	FISCAL YEAR 1979 FUNDING $216,500
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $216,500

OBJECTIVE

The project goal is to provide data on techniques for low-cost containment of molten salt storage media.

APPROACH

The project required (1) developing internal insulation techniques for molten salt storage tanks through a program of laboratory screening material tests, (2) analyzing thermocline performance and the influence of wall convection, and (3) performing storage system parametric analysis to determine most economic tankage strategy (hot/cold, thermocline, or cascade) for different storage capacities.

STATUS

Testing and analyses are complete; the final report is to be issued early in FY 1980.

FUTURE EFFORT

A subscale competitively bid research experiment, which demonstrates some of the major findings of this project, will be initiated in FY 1980.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-26

CONTRACTOR/ADDRESS	TITLE
Martin Marietta Aerospace Corporation Denver Division P. O. Box 179 Denver, Colorado 80201	Storage Fluid Evaluation
	CONTRACT NO. PO #83-2754
PRINCIPAL INVESTIGATOR T. R. Heaton	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Denver, Colorado	FISCAL YEAR 1979 FUNDING $55,378
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $55,378

OBJECTIVE

The purpose of this effort is to provide engineering and chemical data regarding the changes in hydrocarbon oil with exposure to high temperature. The data is to be used to define treatment of the fluid to extend its life in a thermal storage application.

APPROACH

A side-stream vacuum distillation unit is to be built and tested to evaluate the effect of removal of the high- and low-boiling components on the high-temperature stability of the fluid. Fluid replenishment rate data with and without the distillation unit will be compared to assess the need for a side-stream processor.

STATUS

Testing of a system with a vacuum distillation unit and a pressurized system without a distillation unit is complete. Testing of a vented system without a distillation unit is underway.

FUTURE EFFORT

Test data will be analyzed and the design requirements for a side-stream processor will be established.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-27

CONTRACTOR/ADDRESS	TITLE
McDonnell Douglas Astronautics Co. 5301 Bolsa Avenue Huntington Beach, California 92647	2nd Generation Heliostat Development
	CONTRACT NO. 83-0024A
PRINCIPAL INVESTIGATOR D. Steinmeyer	PERIOD OF PERFORMANCE July 28, 1979 to February 28, 1981
WORK LOCATION Huntington Beach, California	FISCAL YEAR 1979 FUNDING $448,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $448,000

OBJECTIVE

One of the contract objectives is to provide a high-performance, low life-cycle cost heliostat design that can be volume produced at rates of 25,000-50,000 per year with an assumed 30-year plant lifetime. Designs and costs should address manufacturing, assembly, installation, and maintenance approaches and should be made available to the solar community. Stimulation of broader industry participation in the DOE solar energy program is also an objective.

APPROACH

McDonnell Douglas plans to design, build, and test two prototype heliostats based on the prototype design developed under study contract with the possible incorporation of a non-inverting drive unit and increased area. Production facility design and cost estimate backup is to be provided by the subcontractor, Giffels Associates.

STATUS

At the program kickoff meeting on October 3, 1979, the baseline design and intended tradeoffs were presented. A management plan and limited test plan have been submitted.

FUTURE EFFORT

A preliminary design review is scheduled for January 1980 and a final design review is scheduled for January 1981. A detailed design report is to be completed by April 1980 and a prototype heliostat is to be delivered for testing in December 1980. The project's final report is scheduled for release in February 1981.

Subcontractor: Giffels Associates, Inc.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-28

CONTRACTOR/ADDRESS	TITLE
McDonnell Douglas Astronautics Co. 5301 Bolsa Avenue Huntington Beach, California 92647	Non-Inverting Heliostat Study
	CONTRACT NO. Sandia 18-7872
PRINCIPAL INVESTIGATOR J. B. Blackmon	PERIOD OF PERFORMANCE August 25, 1978 to April 29, 1979
WORK LOCATION Huntington Beach, California	FISCAL YEAR 1979 FUNDING $51,078
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $51,078

OBJECTIVE

The purpose of this study was to investigate the implications of employing a non-inverting heliostat design where vertical stow is normally used and mirror-up stow is used to survive extreme winds. The effects of the lack of capability to invert were investigated in two principal areas: (1) washing effects and frequency due to possible added dust buildup and (2) increased heliostat damage probabilities, due to hail effects. Identification of any additional safety issues, affecting the ability to meet beam safety criteria for a non-inverting design, and life-cycle cost impacts of heliostat damage due to wind or hail as a function of glass thickness were also investigated.

APPROACH

Data from the recent dust buildup program was analyzed and evaluated for dust buildup rates as a function of stowage position. Previous hail tests results were reviewed in conjunction with historical weather data to predict heliostat field losses. Results of the Sandia Safety Study (GLINT) were used to (1) examine the probability of beam cross-over and (2) identify any additional safety criteria.

STATUS

The contract was completed and a report was published in August 1979. Capital cost savings of 12-13% were associated with using a non-inverting version of a current inverting design in a 100-MWe plant. No additional hail or beam safety hazards were identified.

FUTURE EFFORT

No further activities are planned.

Bibliography Reference No.: 17

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-29

CONTRACTOR/ADDRESS	TITLE
McDonnell Douglas Astronautics Co. 5301 Bolsa Avenue Huntington Beach, California 92647	Test Rocketdyne Receiver
	CONTRACT NO. 83-4746
PRINCIPAL INVESTIGATOR R. Hallet	PERIOD OF PERFORMANCE August 13, 1979 to February 1, 1980
WORK LOCATION Huntington Beach, California	FISCAL YEAR 1979 FUNDING $255,013
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $488,013

OBJECTIVE

The project purpose is to provide testing support for the McDonnell Douglas/Central Receiver Test Facility receiver test. The contractor is responsible for the operation, control, and maintenance of the receiver and reduction of the test data.

APPROACH

The McDonnell Douglas CRTF test plan, test procedures, and control strategy have been developed from the conceptual design for the Barstow receiver. The CRTF test data will be used to validate and/or improve the receiver design for Barstow.

STATUS

Testing will be completed in 1979, with the receiver to be held ready for additional testing, if required, until May 1980.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-30

CONTRACTOR/ADDRESS	TITLE
Northrup, Incorporated 302 Nichols Drive Hutchins, Texas 75141	2nd Generation Heliostat Development
	CONTRACT NO. 83-2729E
PRINCIPAL INVESTIGATOR J. A. Pietsch	PERIOD OF PERFORMANCE August 28, 1979 to February 28, 1981
WORK LOCATION Hutchins, Texas	FISCAL YEAR 1979 FUNDING $250,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $997,895

OBJECTIVE

This contract has four aims:

- To design and develop a low-cost heliostat at a production rate of 50,000 heliostats per year, with capital, operation, and maintenance cost estimates for a 50-MWe heliostat field.
- To fabricate and test two prototype heliostats.
- To create a conceptual design of a heliostat manufacturing facility for 50,000 heliostats per year with a facility cost estimate. (Booz-Allen & Hamilton subcontract.)
- To design foundation and field assembly and installation techniques with cost estimates (Bechtel subcontract).

APPROACH

Northup is the nucleus of a team which will design and plan the production of heliostats. Bechtel National will design the foundation and heliostat installation procedures. Booz-Allen & Hamilton will review manufacturing options and recommend manufacturing strategies that will allow the production of up to 50,000 heliostats per year.

STATUS

Northrup has design and built two heliostats under contract to the Texas Energy Advisory Council. Northrup is currently testing and evaluating this design, and performing cost/performance tradeoffs to improve and optimize the design.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-30

CONTRACTOR/ADDRESS	TITLE
Northrup, Incorporated 302 Nichols Drive Hutchins, Texas 75141	2nd Generation Heliostat Development
	CONTRACT NO. 83-2729E
PRINCIPAL INVESTIGATOR J. A. Pietsch	PERIOD OF PERFORMANCE August 28, 1979 to February 28, 1981
WORK LOCATION Hutchins, Texas	FISCAL YEAR 1979 FUNDING $250,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $997,895

(continued)

FUTURE EFFORT

A detailed design report is to be completed by May 1980 and a prototype heliostat is to be delivered for testing in November 1980. A final report is scheduled for release in February 1981.

Subcontractors: Booz-Allen & Hamilton, Inc.; Bechtel National, Inc.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-31

CONTRACTOR/ADDRESS	TITLE
Progress Industries 7290 Murdy Circle Huntington Beach, California 92647	Heliostat Drive and Protection System Components
	CONTRACT NO. 83-0035F
PRINCIPAL INVESTIGATOR K. Busche	PERIOD OF PERFORMANCE February 1979 to January 1980
WORK LOCATION Huntington Beach, California	FISCAL YEAR 1979 FUNDING $154,200
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $154,200

OBJECTIVE

The project goal is to design, fabricate, and test (1) a cable drive system for a pedestal-type heliostat and (2) a protective cover and cleaning system for the reflective surface. Production, operating, and maintenance cost estimates are to be prepared to determine whether such systems would be more cost-effective than the gear-box-type drive systems and the cleaning or protection approaches currently under development.

APPROACH

Preliminary designs of the cable drive system and the protective system will first be derived. Manufacturing, deployment, and operating processes will also be defined. Production, operating, and maintenance costs will then be estimated for various production rates and summarized in a preliminary design report. More detailed design and cost information will then be developed for the best designs. Component prototype hardware will be fabricated and tested, and all information will be summarized in a final report.

STATUS

Preliminary design and costing activities are essentially complete. The draft preliminary design report was received in September 1979 and is now being revised by the contractor to incorporate more detailed information. Prototype fabrication has been temporarily suspended until the revised preliminary design report is received and approved.

FUTURE EFFORT

Remaining work includes additional detail design, cost performance evaluations, prototype fabrication and testing, and preparation of detail design and final reports.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-32

CONTRACTOR/ADDRESS	TITLE
Schumacher & Associates, Inc. 2550 Fair Oaks Boulevard Suite 120 Sacramento, California 95825	New Ideas for Heliostat Reflector Cleaning Systems
	CONTRACT NO. 83-0035K
PRINCIPAL INVESTIGATOR J. Schumacher	PERIOD OF PERFORMANCE March 12, 1979 to December 31, 1979
WORK LOCATION Sacramento, California	FISCAL YEAR 1979 FUNDING $43,450
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $43,450

OBJECTIVE

The contract objective is to develop and evaluate methods of cleaning glass heliostat mirrors without the use of water. Air-flow cleaning methods will be evaluated under laboratory conditions using mirrors upon which dust is deposited in a wind tunnel. The conceptual design of a full-scale cleaning system will be used for preliminary estimates of the cost for cleaning a 100-MWe field of heliostats.

APPROACH

Vortex-generating orifices and ultrasonic electro-mechanical transducers, to impart energy through air to the surface to be cleaned, are to be fabricated and tested. Dust is to be deposited on the mirrors in a wind tunnel. Cleaning effectiveness is to be measured using a low-cost reflectometer which is to be developed under this contract.

STATUS

The following contract efforts were completed as of August 15, 1979:

- Fabrication of a dust deposition wind tunnel.
- Fabrication of a reflectometer.
- Fabrication and evaluation of a scale-model vortex generator and ultrasonic air transducers for cleaning mirrors.
- Creation of a final report with cleaning cost estimates.

FUTURE EFFORT

Six reflectometers will be built for use by other contractors; a completion date of December 31, 1979 is scheduled.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

CONTRACTOR/ADDRESS	TITLE
Solaramics, Inc. 1301 E. El Segundo Boulevard El Segundo, California 90245	Foamed Glass
	CONTRACT NO. 83-0035J
PRINCIPAL INVESTIGATOR H. E. Felix	PERIOD OF PERFORMANCE March 7, 1979 to February 28, 1980
WORK LOCATION El Segundo, California	FISCAL YEAR 1979 FUNDING $242,500
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $242,500

OBJECTIVE

The purpose of this project is to develop and demonstrate a foamed glass production process. The continuous process demonstration is intended to demonstrate the feasibility of making a full-scale foam glass substrate for heliostat mirrors.

APPROACH

A low-cost subscale system is to be developed to provide 18-inch-wide test samples to assure meeting environmental and other design requirements. Design of a full-scale (48-inch-wide) system is to be started; full-scale fabrication and installation is dependent on satisfactory completion of the subscale program.

A continuous ribbon of foamed glass is to be produced by sintering, foaming, annealing, and slow cooling of the raw material as it is carried along a continuous conveyor belt through appropriate temperature zones. At the end of these zones, the foamed glass ribbon is to be cut to the desired lengths and sorted in a shelved annealing box.

STATUS

A subscale kiln has been built and used, but the results were not entirely satisfactory; the conveyor belt tended to walk off of the rollers and the application of a mold release was more difficult than expected. As a result, material samples for test and evaluation have not been fabricated as required. A revised program plan to complete the required task has been completed.

FUTURE EFFORT

The subscale system will be used for one full month of production to demonstrate the proce and to provide material for testing. A full-scale kiln will not be fabricated.

Subcontractor: Approved Engineering Test Laboratories

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-34

CONTRACTOR/ADDRESS	TITLE
Solaramics, Inc. 1301 E. El Segundo Boulevard El Segundo, California 90245	Heliostat Drive Mechanism
	CONTRACT NO. 83-0024C
PRINCIPAL INVESTIGATOR H. E. Felix	PERIOD OF PERFORMANCE October 16, 1978 to July 15, 1979
WORK LOCATION El Segundo, California	FISCAL YEAR 1979 FUNDING $250,900
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $250,900

OBJECTIVE

The objective of this contract effort has been to design and test the modified azimuth-elevation heliostat drive mechanism generated by Solaramics in the Low-Cost Heliostat Preliminary Design Program (contract #ET-78-C-03-1745).

APPROACH

The preliminary design has been scaled up to accommodate a larger heliostat of $50m^2$ (524 sq.ft.) from the $40m^2$ design.

The design effort has stressed development of a mechanism possessing low initial cost and low maintenance. The basic design concept utilizing two linear actuators with bell crank linkages has been retained and refined.

STATUS

A full-scale assembly has been fabricated and tested to evaluate performance characteristics.

A modified azimuth elevation drive mechanism concept has been developed which embodies an azimuth axis inclined 23° from vertical. The tilted axis is in line with a vector to the receiver and is tilted away from the receiver. This concept has the advantage of shifting the location of control singularities outside the operational zone of the tracking requirements. It also reduces the azimuth drive requirement to less than 180° compared to approximately 240° for typical azimuth-elevation systems. The elevation requirement is increased from 180° to 203° to achieve an inverted stowage position.

FUTURE EFFORT

Additional testing is planned.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

35

CONTRACTOR/ADDRESS	TITLE
Springborn Laboratories Enfield, Connecticut 06082	Prevention of Soiling of Heliostat Surfaces
	CONTRACT NO. 83-0035G
PRINCIPAL INVESTIGATOR	PERIOD OF PERFORMANCE
R. E. Cambron	March 26, 1979 to March 26, 1980
WORK LOCATION	FISCAL YEAR 1979 FUNDING
Enfield, Connecticut	$153,563
CONTRACTING OFFICE	CUMULATIVE FUNDING
Sandia Laboratories Livermore, California	$153,563

OBJECTIVE

The goal of this research is to develop treatments for the glass surface or plastic dome covering an aluminized Mylar mirror of a heliostat to prevent or minimize soiling and to facilitate cleaning.

APPROACH

Various antistatic and antisoiling agents will be examined to determine which materials would produce the highest efficiency in the reduction of soiling on glass or plastic surfaces. These materials are either reactive with glass or plastic themselves, reactive with a coupling agency such as a silane or titanate, or compatible with a carrier such as weather-resistant coating.

The organic compounds known to be reactive with hydroxyl groups will be attached directly to the glass surface. Other organic compounds will be grafted to the plastic or glass surfaces using silane or titanate coupling agents. Antistats or soil-release agents which are compatible with weather-resistant coating vehicles, such as acrylics, silicones, or fluorocarbons, will be blended with the carrier and coated on the glass or plastic surface.

STATUS

Screening tests of the treated surfaces have been conducted to determine the best agents for the reduction of soiling and whether or not the treatment process is economically feasible when compared to standard washing procedures. These testing procedures include determinations of clarity, hardness, abrasion resistance, antistatic properties, anti-soiling properties, and permanence.

FUTURE EFFORT

Recommendations for future effort depend on the outcome of the experiments scheduled.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-36

CONTRACTOR/ADDRESS	TITLE
Stearns-Roger Engineering Co. P.O. Box 5888 Denver, Colorado 80217	Receiver Tower Cost Study
	CONTRACT NO. PO # 18-8466
PRINCIPAL INVESTIGATOR W. Lang	PERIOD OF PERFORMANCE August 7, 1978 to September 30, 1979
WORK LOCATION Denver, Colorado	FISCAL YEAR 1979 FUNDING $106,584
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $120, 460

OBJECTIVE

The goal of this study was to obtain tower cost data for use in current and future solar central receiver studies.

APPROACH

Thirty-three separate cases were evaluated, each with its own set of tower variables and environmental variables. Some of the variables examined were tower type (concrete or steel), receiver weight, ground acceleration, and wind velocity. Towers from 120 feet to 1,000 feet were studied.

STATUS

The contract was completed when the Stearns-Roger report was delivered to Sandia Laboratories, Livermore (SLL) in July 1979. The report is now available through DOE's Technical Information Center.

FUTURE EFFORT

SLL is developing a tower cost algorithim that uses the Stearns-Roger data to predict tower costs over the entire range of variables of the study.

Bibliography Reference No.: 16

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components

D-37

CONTRACTOR/ADDRESS	TITLE
Sun Power Corporation 55 Miller Street Fairfield, Connecticut 06430	Feathering Heliostats and Drive Systems
	CONTRACT NO. 83-0035L
PRINCIPAL INVESTIGATOR C. L. Whiteford	PERIOD OF PERFORMANCE March 1979 to September 1979
WORK LOCATION Fairfield, Connecticut	FISCAL YEAR 1979 FUNDING $30,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $30,000

OBJECTIVE

The project objective is to investigate alternate concepts for a heliostat drive mechanism that would reduce heliostat costs by allowing the heliostat mirror structure to fold and feather into the wind to reduce wind loads and provide protection for the mirror surfaces.

APPROACH

The contractor will perform trade-off studies for the different concepts to provide information relative to costs, producibility, and required development effort. The most promising concepts will be developed to a conceptual design level such that one or more of the concepts can be carried through the preliminary design phase. The contractor will provide recommendations for further development.

STATUS

The initial investigations supported by this contract have been completed, and the report summarizing the work was received in September 1979. The contractor has proposed follow-on fabrication and test of key elements of the design to show feasibility and to develop a better base for costing.

FUTURE EFFORT

The desirability of follow-on work is under consideration in light of the potential of the concept, available funds, and other priorities.

ELEMENT: Central Receiver Systems

SUB-ELEMENT: Subsystems and Components D-38

CONTRACTOR/ADDRESS	TITLE
Westinghouse Electric Corp. Advanced Energy Systems Division P. O. Box 10864 Pittsburgh, Pennsylvania 15236	2nd Generation Heliostat Development Program
	CONTRACT NO. 83-2729D
PRINCIPAL INVESTIGATOR R. W. Devlin	PERIOD OF PERFORMANCE July 16, 1979 to February 28, 1981
WORK LOCATION Pittsburgh, Pennsylvania	FISCAL YEAR 1979 FUNDING $200,000
CONTRACTING OFFICE Sandia Laboratories Livermore, California	CUMULATIVE FUNDING $200,000

OBJECTIVE

One of the contract objectives is to provide a high-performance, low life-cycle cost heliostat design that can be volume-produced at rates of 25,000-50,000 per year with an assumed 30-year plant lifetime. Designs and costs should address manufacturing, assembly, installation, and maintenance approaches, and should be made available to the solar community. Stimulation of broader industry participation in the DOE solar energy program is also an objective.

APPROACH

The approach taken by Westinghouse is to use a design similar to their demonstration heliostat but adding refinements as tradeoffs indicate increased performance or lower cost. Design features include open low-profile structure, three post foundation, laminated glass mirrors with edge seal, and induction motors with cable drive. Another feature is field assembly rather than one manufacturing plant.

STATUS

The program kickoff meeting took place on September 14, 1979.

FUTURE EFFORT

A prototype design review is scheduled for February 1980 and a detailed design review is scheduled for May 1980. After the baseline design is refined, two heliostats will be manufactured and then tested at Sandia's Central Receiver Test Facility (CRTF). A manufacturing plan and cost estimates will be provided.

ADVANCED THERMAL TECHNOLOGY

E. Materials Technology
Project Summaries

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology E-1

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Supporting Materials Research for Solar Thermal Program
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR B. L. Butler	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Golden, Colorado	FISCAL YEAR 1979 FUNDING $846,000
CONTRACTING OFFICE Chicago Operations Office Chicago, Illinois	CUMULATIVE FUNDING $846,000

OBJECTIVE

The purpose of this program has been to conduct research and development (R&D) to define new or improved materials which can be made available to system designers through direct commercialization or process development. These improved materials will lower life-cycle costs by reducing initial cost, improving performance, or increasing the useful lives of solar components.

APPROACH

A general solar materials R&D plan including reflectors, transmitters, absorbers, energy transfer materials, containers, and structures has been developed to guide both SERI and materials researchers.

Scientists selected from U. S. Government national laboratory staffs served on committees which drafted the various sections of a 5-year materials R&D plan. Additional scientists from national laboratories, universities, and industries participated in meetings which provided important guidance to those planning committees. Based on these plans and input from DOE's Solar Thermal Program Office, a SERI materials research plan was developed which emphasizes reducing silver mirror corrosion, thin glass development, black cobalt selective absorbers, polymer degradation, thermal system corrosion monitoring, and high-temperature ceramic materials.

STATUS

Significant progress has been made in the areas of reducing mirror degradation, thin glass development, black cobalt selective absorbers, polymer degradation, corrosion monitoring, and ceramic materials.

A new accelerated degradation test has been developed to evaluate silvered glass mirrors. The tests involve potentiostaticly driven electrochemical attack leading to rapid degradation which correlates well with real-time service lives.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Supporting Materials Research for Solar Thermal Program
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR B. L. Butler	**PERIOD OF PERFORMANCE** October 1, 1978 to September 30, 1979
WORK LOCATION Golden, Colorado	**FISCAL YEAR 1979 FUNDING** $846,000
CONTRACTING OFFICE Chicago Operations Office Chicago, Illinois	**CUMULATIVE FUNDING** $846,000

(continued)

A new chemical process has been developed for the electrodeposition of black cobalt selective absorbers. The new process reduces the rate of degradation of the absorber's optical properties at high temperatures.

A new technique of high sensitivity Fourier transform interference spectrometry is being used to study the degradation of a polycarbonate model polymer. The influence of solar irradiation, atmospheric pollutants, and their synergistic interactions are being evaluated.

A new alternating current corrosion monitoring technique is being developed for use in both high-temperature and low-temperature solar systems.

An apparatus to measure the static fatigue (slow crack growth) of glass and ceramics has been placed in operation. Slow crack growth rate measurements are required for both evaluation of new materials during development and generation of engineering design data for the commercialization of developed materials.

FUTURE EFFORT

The planning activity will be updated at the request of DOE when appropriate. The SERI in-house R&D activities are to be a continuing effort and are to yield more information on the methods of improving materials performance and lifetimes per unit cost in solar thermal energy conversion systems.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology E-2

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Chemical Vapor Deposition of Refractory-Metal Reflectors for Spectrally Selective Solar Absorbers
	CONTRACT NO. XH-9-8217-1
PRINCIPAL INVESTIGATOR B. O. Seraphin	PERIOD OF PERFORMANCE March 15, 1979 to March 14, 1980
WORK LOCATION University of Arizona Tucson, Arizona	FISCAL YEAR 1979 FUNDING $136,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $276,000

OBJECTIVE

The project objective is twofold:

- To develop chemical vapor deposition technologies.
- To produce optical multilayer stacks which are spectrally selective, stable at temperatures greater than 500 ^{o}C, and economically attractive to large-scale manufacturers.

APPROACH

A multilayer stack which is comprised of a diffusion barrier at the substrate surface, followed by a metal reflector layer, a diffusion barrier, a semiconductor absorber layer, and an antireflection surface coating is to be produced.

STATUS

A highly efficient stable film using CVD Mo has been developed with absorptance values equal to the standard and minimum emittance. Stacks that can be fabricated entirely by CVD have been produced with Mo in place of Ag. An Si_3N_4 layer replaces the Cr_2O_3 diffusion barrier layer. This film has similar optical properties to the Ag/Si multilayer and has been stressed for 1,000 hours at 550 ^{o}C in air with localized (and explainable) degradation. In addition, a black molybdenum-Si_3N_4 absorber stack has demonstrated α >0.91 in vacuum.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Chemical Vapor Deposition of Refractory-Metal Reflectors for Spectrally Selective Solar Absorbers
	CONTRACT NO. XH-9-8217-1
PRINCIPAL INVESTIGATOR B. O. Seraphin	PERIOD OF PERFORMANCE March 15, 1979 to March 14, 1980
WORK LOCATION University of Arizona Tucson, Arizona	FISCAL YEAR 1979 FUNDING $136,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $276,000

(continued)

FUTURE EFFORT

Future activities include:

- Demonstrating that absorptance can be increased to 0.90 using amorphous semiconductors as absorbers.
- Improving process control for consistent high IR reflectance from CVD Mo.
- Continuing to investigate the oxidation resistance of Mo containing stacks.
- Defining parameters for the most optically efficient absorber stacks.
- Simplifying the absorber stacks by elimination of diffusion barrier layers.

Subcontractor: University of Arizona (Optical Sciences Center)

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology E-3

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Oxidative Degradation of Polypropylene by Copper Oxides
	CONTRACT NO. RP-9-8172-1
PRINCIPAL INVESTIGATOR Dr. Jellinek	PERIOD OF PERFORMANCE September 1, 1979 to August 31, 1980
WORK LOCATION Clarkson College of Technology Potsdam, New York	FISCAL YEAR 1979 FUNDING $72,500
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $72,500

OBJECTIVE

The aim of this project is to investigate the importance of copper ions at copper/polymer interfaces and evaluate means to inhibit this catalytic action.

APPROACH

Four tasks are entailed in this project:

- Determination of the degradation sites.
- Determination of the copper oxide yielding the greatest catalytic reaction (CuO or Cu_2O).
- Evaluation of the use of copper-alloy oxide films to inhibit degradation.
- Evaluation of candidate polymers.

STATUS

Work is scheduled to begin as of September 1979.

Subcontractor: Clarkson College of Technology

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology

E-4

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Optical Properties of Metallic Surfaces, Small Particles, and Composite Coatings
	CONTRACT NO. XH-9-8158-1
PRINCIPAL INVESTIGATOR A. J. Sievers	PERIOD OF PERFORMANCE April 1, 1979 to March 31, 1980
WORK LOCATION Cornell University Ithaca, New York	FISCAL YEAR 1979 FUNDING $140,528
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $328,794

OBJECTIVE

The purpose of this project is to investigate the optical and physical properties of metals, alloys, and composite coatings.

APPROACH

A theoretical model explaining the interactions of metal particles with light will be developed, and metal smokes and metal dispersion in insulators as selective solar absorbers will be experimentally investigated.

STATUS

An advanced multiple scattering theory of metal particle-light interactions has been developed. The theory includes the nonuniform distribution of particle shapes and sizes in composite coatings.

Dispersions of Ni, V, Fe, and Pt in Al_2O_3, SiO, and MgO have been produced by dual beam evaporation. The Ni/Al_2O_3 cermet with $\alpha_s = 0.94$ e_t (100 °C) = 0.16 and e_t (500 °C) = 0.35 appears to be stable at 500 C. Pt/Al_2O_3 shows a_t (500 °C) >0.1.

FUTURE EFFORT

Four additional tasks will be pursued:

- Absorption and reflectivity parameters for the use of inexpensive metals as components of solar reflectors and absorbers will be optimized.
- Optical and physical properties of metals, metal alloys, and cermet composites will be evaluated, and experimental verification of theoretical optimum parame will be sought.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology E-4

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Optical Properties of Metallic Surfaces, Small Particles, and Composite Coatings
	CONTRACT NO. XH-9-8158-1
PRINCIPAL INVESTIGATOR A. J. Sievers	PERIOD OF PERFORMANCE April 1, 1979 to March 31, 1980
WORK LOCATION Cornell University Ithaca, New York	FISCAL YEAR 1979 FUNDING $140,528
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $328,794

(continued)

- o A stable, efficient cermet absorber will be developed with improved efficiency and high-temperature stability.
- o Straightforward protocols for the engineering of composites to match particular solar applications will be established.

Subcontractor: Cornell University (Atomic and Solid State Physic Lab)

ELEMENT: Thermal Technology

SUB-ELEMENT: Materials Technology

E-5

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Evaluation for Thin Glass
	CONTRACT NO. AJ-9-8099-1
PRINCIPAL INVESTIGATOR A. Shoemaker	PERIOD OF PERFORMANCE May 14, 1979 to August 17, 1979
WORK LOCATION Corning Glass Works Harrodsburg, Kentucky	FISCAL YEAR 1979 FUNDING $197,092
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $197,092

OBJECTIVE

The project objective is threefold:

- To explore the melting and forming characteristics of 780X glass.
- To explore the limits of the fusion process for producing sheet glass to 0.25 mm thickness.
- To select pieces of glass at each thickness for evaluation and determination.

APPROACH

Fusion melt is to be prepared under observation of a SERI monitor, and blanks down to 0.25 mm are to be produced to evaluate the characteristics of the glass.

STATUS

A pilot run of 780X glass was completed and glass down to 1.0 mm was produced with excellent optical and surface characteristics. Shipments to parties interested in evaluating the glass have also been completed.

FUTURE EFFORT

780X glass is to be produced in the Blacksburg, Virginia, facility and a method for cutting solar glass is to be developed.

Subcontractor: Corning Glass Works, Technical Products Division

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology E-6

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Development of Reflective Surface Protective Coatings
	CONTRACT NO. XJ-9-8091-1
PRINCIPAL INVESTIGATOR W.E. Dennis	PERIOD OF PERFORMANCE March 14, 1979 to May 14, 1980
WORK LOCATION Dow Corning Corporation Midland, Michigan	FISCAL YEAR 1979 FUNDING $70,213
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $71,000

OBJECTIVE

The aim of this project is to develop reflective surface protective coatings which will be inexpensive, have long life, and cause attenuation of the reflected solar radiation.

APPROACH

This project will be conducted in three phases:

- In Phase I, aluminized float glass will be coated with various silicone resins, and each sample will be evaluated.
- In Phase II, the best candidates from Phase I will be tested and optimized. An economic evaluation of the coatings will be included.
- In Phase III, the adhesion of resin coatings to silver-coated surfaces will be of prime concern.

STATUS

Four resins have been successfully coated on aluminized float glass squares. Optical measurements and environmental testing of these samples are continuing.

FUTURE EFFORT

Coating development will be continued and further testing on samples with less than .92 reflectance will be deleted. Ability of samples to withstand weathering and repeated cleaning will be investigated.

Subcontractor: Dow Corning Corporation

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology E-7

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Improved Absorber Coatings for Thermal Utilization of Solar Energy
	CONTRACT NO. XJ-9-8008-1
PRINCIPAL INVESTIGATOR Dr. Lanam	PERIOD OF PERFORMANCE May 22, 1979 to September 30, 1980
WORK LOCATION Englehard Mineral & Chemical Co. Edison, New Jersey	FISCAL YEAR 1979 FUNDING $132,339
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $254,000

OBJECTIVE

The purpose of this contract is to develop selectively absorbing films prepared by the thermal decomposition of metallo-organic solutions for solar receivers at 300 ^{o}C to 700 ^{o}C.

APPROACH

Matrix films based on earlier work by Englehard Industries for space applications will be prepared by applying metallo-organic solutions to glass, quartz, or metallic substrates and air firing at 500 ^{o}C to 800 ^{o}C.

STATUS

Research, thus far, has yielded the following results:

- The α has been increased from 0.5 to 0.8 with ε_t (300 ^{o}C) = 0.06 and ε_t (540 ^{o}C) = 0.06 for gold matrix films by compositional and preparatory modifications.
- A silver matrix, copper oxide film doped with rhodium oxide has been developed. A α_s of 0.91 has been achieved and the absorptance can be stabilized at 500 ^{o}C by increasing the percentage of CuO. However, the hemispherical emittance increases with increasing CuO.
- The agglomeration of Ag has been identified as a high-temperature degradation mechanism.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology E-7

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Improved Absorber Coatings for Thermal Utilization of Solar Energy
	CONTRACT NO. XJ-9-8008-1
PRINCIPAL INVESTIGATOR Dr. Lanam	PERIOD OF PERFORMANCE May 22, 1979 to September 30, 1980
WORK LOCATION Englehard Mineral & Chemical Co. Edison, New Jersey	FISCAL YEAR 1979 FUNDING $132,339
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $254,000

(continued)

FUTURE EFFORT

A metallo-organic system with α_s = 0.9, ϵ_t (500 ^{o}C) = 0.1 and long-term stability in air and vacuum at 500 ^{o}C will be developed, and film composition will be varied to stabilize the Ag agglomeration.

Subcontractor: Englehard Mineral and Chemical Company, Englehard Industries Division

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	High-Temperature Solar Absorber Coatings
	CONTRACT NO. XJ-9-8009-1
PRINCIPAL INVESTIGATOR A. H. Muenker	PERIOD OF PERFORMANCE December 19, 1978 to February 18, 1980
WORK LOCATION Exxon Research and Engineering Company Linden, New Jersey	FISCAL YEAR 1979 FUNDING $98,143
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $177,000

OBJECTIVE

The project goal is to develop low-cost high-temperature receiver coatings that can be applied using conventional paint spraying techniques and that are amenable to "in place" repair. The coating must have $\alpha \gtrsim 0.95$ and mechanical and optical stability to 700 ^{o}C.

APPROACH

Coatings pigmented with (Fe-Mn-Cu) O_x in lithium silicate bases are to be prepared, and the pigment to vehicle ratios (PVR) is to be varied. In addition, coatings are to be evaluated after environmental exposure at high temperature.

STATUS

Coatings have been prepared and tested with $\alpha_{700} \gtrsim 0.96$.

FUTURE EFFORT

Other coatings using other selected pigments such CoO, Co_3O_4, Mn_3O_4 and Mn_2O_3 will be evaluated.

Subcontractor: Exxon Research and Engineering Company, Government Research Laboratories

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology E-9

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Surface Morphologies of Efficient Solar Energy Absorbing Materials
	CONTRACT NO. XJ-9-8192-1
PRINCIPAL INVESTIGATOR A. Ignatiev	PERIOD OF PERFORMANCE June 1, 1979 to September 30, 1980
WORK LOCATION EFT/University of Houston Houston, Texas 77004	FISCAL YEAR 1979 FUNDING $98,200
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $174,000

OBJECTIVE

This project has a dual purpose:

- The role of surface morphology and microstructure in defining the optical absorption and emission of absorber coatings is to be determined.
- The optical properties of laboratory and commercial gold, chrome, and nickel blacks are to be compared.

APPROACH

A two-part approach is to be pursued:

- Produce and corroborate a theory that relates the microstructure and optical properties of black metal film.
- Investigate the implications of this theory in producing improved absorber coatings.

STATUS

A mean field continuum model was developed based on previous work on gold black that showed the applicability of this theory in describing the optical properties of dispersed metallic particles in dielectric media.

SEM/ESCA studies suggest that the microstructure for electroplated black chrome is: a 200 to 300 Å surface layer of loosely packed Cr_2O_3 particles and (2) several layers of loosely packed 1000 to 2000 Å diameter chromium particles, each coated with a thin oxide layer.

Theoretical calculations indicate that a film with $\alpha_s = 0.92$ and ε_t (120 ^{o}C) = 0.036 can be achieved with a black gold 0.8 mm thick layer comprised of a mixture of spheres and ellipsoids.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology

E.9

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Surface Morphologies of Efficient Solar Energy Absorbing Materials
	CONTRACT NO. XJ-9-8192-1
PRINCIPAL INVESTIGATOR A. Ignatiev	PERIOD OF PERFORMANCE June 1, 1979 to September 30, 1980
WORK LOCATION EFT/University of Houston Houston, Texas 77004	FISCAL YEAR 1979 FUNDING $98,200
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $174,000

(continued)

FUTURE EFFORT

Five additional tasks are to be carried out:

- Investigate the basis of optical degradation of black chrome, black cobalt, and Pyromark. (Conditions to be explored include heating to 700 ^{o}C and various controlled atmospheres.)
- Evaluate the role of substrates in the degradation of solar absorbers.
- Evaluate enhanced degradation due to high photon flux environment.
- Study the relationship of particle size and oxidation behavior in absorber coatings.
- Develop statements of the interrelationships between the coating, photon flux, temperature, and environment.

Subcontractor: Energy Foundation of Texas (EFT)/University of Houston

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology E-10

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Composition Profiling of Solar Coating Materials
	CONTRACT NO. XM-9-8289-1
PRINCIPAL INVESTIGATOR G. K. Wehner	PERIOD OF PERFORMANCE May 1, 1979 to April 30, 1980
WORK LOCATION University of Minnesota Minneapolis, Minnesota	FISCAL YEAR 1979 FUNDING $57,848
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $167,277

OBJECTIVE

The purpose of this project is to provide analytical support for other absorber surface contractors and investigate sputtering techniques for producing surfaces with high solar absorptance and high-temperature stability.

APPROACH

Three tasks are entailed in pursuing the project objective:

- Apply Auger Electron Spectroscopy (AES) and Electron Spectroscopy for Chemical Analysis (ESCA) to supplied samples for the determination of atomic and chemical depth profiles.
- Aid in the analysis of the production and degradation of absorber coatings.
- Apply state-of-the-art sputter technology toward the development of a high-temperature stable multilayer interface.

STATUS

Solar absorber coatings were analyzed for the University of Arizona chemical vapor deposition (CVD) multistack program. It was determined that a 15-minute heat treatment of stainless steel at 900 ^{o}C produces a dense Cr_2O_3 film which is an excellent diffusion barrier. Sputter deposition of an AMA-Mo multilayer stack on a heat-treated stainless steel tube was concluded to be an economically viable approach to high-temperature selective absorber coatings.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology

E-10

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Composition Profiling of Solar Coating Materials
	CONTRACT NO. XM-9-8289-1
PRINCIPAL INVESTIGATOR G. K. Wehner	PERIOD OF PERFORMANCE May 1, 1979 to April 30, 1980
WORK LOCATION University of Minnesota Minneapolis, Minnesota	FISCAL YEAR 1979 FUNDING $57,848
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $167,277

(continued)

FUTURE EFFORT

Other service measurements using AES and ESCA will be provided to several SERI subcontractors. Additionally, a collaboration will be undertaken with SERI and Honeywell to study the failure mechanisms of black cobalt and to study a novel technique for applying black cobalt.

Subcontractors: University of Minnesota

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology E-11

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Technical Support of Cellular Glass Programs
	CONTRACT NO. XL-9-8070-1
PRINCIPAL INVESTIGATOR W. F. Carroll	PERIOD OF PERFORMANCE February 22, 1979 to November 21, 1979
WORK LOCATION Jet Propulsion Laboratory Pasadena California	FISCAL YEAR 1979 FUNDING $120,960
CONTRACTING OFFICE NASA Resident Procurement Office Pasadena, California	CUMULATIVE FUNDING $120,960

OBJECTIVE

This contract has a twofold objective:

- o To plan and coordinate broad-based programs for materials technology programs.
- o To provide a lead center for planning and management of cellular glass technology.

APPROACH

Four kinds of tasks are to be conducted under this contract:

- o Perform cost/risk/benefit analyses.
- o Participate in and conduct long-range planning activities.
- o Prepare and review planning documents.
- o Develop a comprehensive plan for cellular glass technology development.

STATUS

Polymer and transmitter program plans are being developed and a process for continuous fabrication of cellular glass is being developed under subcontract.

FUTURE EFFORT

Parameters for the manufacture of durable cellular glass will be defined and K_o for stress factor will be determined.

Subcontractor: NASA's Jet Propulsion Laboratory

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology

E-12

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Evaluation of Vacuum Deposition as a Technique for Producing Solar Receiver Coatings
	CONTRACT NO. RH-9-8260
PRINCIPAL INVESTIGATOR J. A. Thornton	PERIOD OF PERFORMANCE January 15, 1980 to January 4, 1981
WORK LOCATION Telic Corporation Santa Monica, California	FISCAL YEAR 1979 FUNDING $103,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $103,000

OBJECTIVE

The project objective is twofold:

- To evaluate vacuum sputtering as a technique for depositing a Pt/Al_2O_3 cermet absorber coating.
- To determine the feasibility for the production of solar absorber coatings on a commercial scale on the variety of geometries anticipated for central receivers.

APPROACH

The coating will be evaluated with respect to optical quality and durability, trade-offs in these properties and coating production costs, and availability of deposition facilities.

STATUS

This contract was under negotiations as of September 12, 1979.

Subcontractor: Telic Corporation

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Materials Technology E-13

CONTRACTOR/ADDRESS	TITLE
Solaramics, Inc. 1301 East El Segundo Boulevard El Segundo, California 90245	Cellular Glass Development
	CONTRACT NO. 955527
PRINCIPAL INVESTIGATOR W. D. Mitchell	PERIOD OF PERFORMANCE July 26, 1978 to May 26, 1979
WORK LOCATION El Segundo, California	FISCAL YEAR 1979 FUNDING $142,870
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $142,870

OBJECTIVE

The goals of this effort were to supply state of the art cellular glass materials to the Jet Propulsion Laboratory (JPL) for property characterization; determine the coefficient of thermal expansion and chemical composition; and report type of foaming agent for materials supplied to JPL.

APPROACH

This project entailed five tasks:

- An analytical evaluation of the structural performance expected of cellular glass panels used as substrate support for mirror glass in parabaloidal solar concentrators was conducted; effects of density variations, wire reinforcement and ribbing were included.
- Cellular glass plates with density varied continuously across the thickness and which provided a high density skin were fabricated; JPL was supplied with optimum density configuration samples.
- Cellular glass with wire reinforcement was fabricated; JPL was supplied with optimum density and reinforcement configuration samples.
- Cellular glass plates using sag-formed or press-assisted methods to make compound curved plates were fabricated; JPL was supplied with optimum density configuration samples based on evaluations done in the first task cited.
- Technical data on achievable limits of variation in pore size and wall thickness at constant bulk density was determined and supplied to JPL.

STATUS

All tasks have been completed; no further activities are contemplated.

ADVANCED THERMAL TECHNOLOGY

F. Advanced Subsystems Project Summaries

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems F-1

CONTRACTOR/ADDRESS	TITLE
Acurex Corporation 485 Clyde Avenue Mountain View, California	An Advanced Solar Concentrator Design
	CONTRACT NO. 955477
PRINCIPAL INVESTIGATOR R. Bedard, Jr.	PERIOD OF PERFORMANCE July 1979 to May 1980
WORK LOCATION Mountain View, California	FISCAL YEAR 1979 FUNDING $275,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $275,000

OBJECTIVE

The project goal is to obtain realistic fabrication costs required to mass produce an 11-meter diameter advanced solar concentrator with reflective elements (which form the paraboloidal reflective surface) fabricated of thin backsilvered glass mirror bonded to contoured substrate of newly developed structural cellular glass.

APPROACH

In order to obtain a realistic mass production cost estimate of the concentrator, a preliminary design of the concept originated at the Jet Propulsion Laboratory is to be conducted first. In addition to meeting certain performance specifications, the design of the advanced concentrator is also aimed at being able to be mass produced with low fabrication cost. The preliminary design is to generate layouts, drawings, and analyses in sufficient detail for the structural, mechanical, control, optical, and electrical subsystems as well as subsystem integration of the entire concentrator. They are then to be used as the basis for the mass production cost analysis effort. Critical components such as the reflective element, which calls for the application of the newly developed structural cellular glass, will require more detailed design study in order that potential capability of the material can be fully utilized.

STATUS

The Acurex Corporation was selected for the performance of the contract in July 1979. Task 1, the preliminary design effort, was scheduled to be completed at the end of October 1979. A preliminary design review was scheduled to be held at the contractor's facility on October 18, 1979.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems

CONTRACTOR/ADDRESS	TITLE
Acurex Corporation 485 Clyde Avenue Mountain View, California	An Advanced Solar Concentrator Design
	CONTRACT NO. 955477
PRINCIPAL INVESTIGATOR R. Bedard, Jr.	PERIOD OF PERFORMANCE July 1979 to May 1980
WORK LOCATION Mountain View, California	FISCAL YEAR 1979 FUNDING $275,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $275,000

(continued)

FUTURE EFFORT

Task 2 (detail design of the cellular glass reflective element) and Task 3 (mass production cost analysis) contractor activities will be pursued.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems F-2

CONTRACTOR/ADDRESS	TITLE
General Electric Company Space Division, Advanced Energy Program P.O. Box 8555 Philadelphia, Pennsylvania 19101	Design, Fabrication, and Acceptance Test of a Heat Pipe Solar Receiver with Thermal Energy Storage
	CONTRACT NO. 955388
PRINCIPAL INVESTIGATOR W. F. Zimmerman	PERIOD OF PERFORMANCE March 1979 to June 1981
WORK LOCATION Evendale, Ohio	FISCAL YEAR 1979 FUNDING $285,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $285,000

OBJECTIVE

The objective of this contract is to design, fabricate, and acceptance test a heat pipe receiver with thermal energy storage (TES) for use with a dish-Stirling solar power system in the 20 kWe power range, demonstrating technology that has potential for low-cost manufacture.

APPROACH

Under a previous Jet Propulsion Laboratory study (Contract No. 955018), various latent and sensible heat thermal energy storage and thermal transport systems using alkali metal technology were investigated. A very promising heat transport and TES subsystem was identified. Under this present contract, design and development of this concept will be performed. Small-scale experiments will be performed to verify heat transport and thermal storage parameters. A prototype receiver with TES will be built, shipped to Edwards Test Station, and acceptance tested.

STATUS

An Alternative Design Concepts Task was started to develop potentially very low-cost designs for heat pipe solar receivers with TES. The TES/Heat Pipe Modular Experiment fabrication is nearing completion.

FUTURE EFFORT

The Modular Experiment will be completed, a fossil fuel combustor experiment will be built and tested, and a preliminary design analysis will be completed for the selected low-cost concept. Detailed design and fabrication of the receiver/TES prototype will then commence.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems

F-3

CONTRACTOR/ADDRESS	TITLE
General Electric Company P. O. Box 15132 Cincinnati, Ohio 45215	High-Temperature Solar Thermal Receiver (Conceptual Design)
	CONTRACT NO. 955455
PRINCIPAL INVESTIGATOR C. S. Robertson	PERIOD OF PERFORMANCE June 6, 1979 to November 15, 1979
WORK LOCATION Cincinnati, Ohio Evendale, Ohio	FISCAL YEAR 1979 FUNDING $126,752
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $126,752

OBJECTIVE

The contract aim is to conduct a study that provides a conceptual design of a solar receiver for industrial processes and high-temperature applications including high-temperature Brayton.

APPROACH

Two tasks are required to meet the project's objective:

- Perform a parametric study based on the design constraints.
- Make use of advanced ceramic materials to provide the most promising receiver concept(s).

STATUS

The parametric study was completed and a receiver concept was recommended.

FUTURE EFFORT

The conceptual design of the selected concept is to be performed, operation and performance requirements are to be determined, and the production cost will be estimated.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems F-4

CONTRACTOR/ADDRESS	TITLE
Sanders Associates, Inc. 95 Canal Street Nashua, New Hampshire 03061	High-Temperature Solar Thermal Receiver (Conceptual Design)
	CONTRACT NO. 955454
PRINCIPAL INVESTIGATOR S. Davis	PERIOD OF PERFORMANCE June 7, 1979 to December 7, 1979
WORK LOCATION Nashua, New Hampshire (Merrimack Facility)	FISCAL YEAR 1979 FUNDING $87,310
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $87,310

OBJECTIVE

The purpose of this project is to conduct a study resulting in a conceptual design of a solar receiver for industrial processes and high-temperature applications, including high-temperature Brayton.

APPROACH

Performance calculations are to be conducted, material is to be selected, and weight is to be estimated on the selected receiver concept for high-temperature applications.

STATUS

A parametric analysis was completed and a receiver concept for conceptual design has been selected.

FUTURE EFFORT

The conceptual design is to be performed, receiver operation and performance requirements are to be indicated, and production cost estimates of the design are to be estimated.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems

CONTRACTOR/ADDRESS	TITLE
Sanders Associates, Inc. 95 Canal Street Nashua, New Hampshire 03061	20 kWe Brayton Solar Power System Component Development
	CONTRACT NO. 955279
PRINCIPAL INVESTIGATOR A. Poirier	PERIOD OF PERFORMANCE November 17, 1979 to March 31, 1980
WORK LOCATION Nashua, New Hampshire	FISCAL YEAR 1979 FUNDING $519,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $704,000

OBJECTIVE

The project aim is to design, fabricate, and test components for use in a 20 kWe Brayton solar power system; specifically, the purpose is to design the thermal storage modules with their associated valving and testing of a high-storage module with valving.

APPROACH

A design point analysis, a detail design, and a regional applications study that will result in a design for a thermal storage module and associated valving are to be performed.

STATUS

Preliminary design and detail design of the thermal storage power modules were completed. High-temperature valves have been designed and parts are being ordered.

FUTURE EFFORT

Fabrication, test, and evaluation of a power module and its associated valving will be undertaken.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems F-6

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Heat Transfer and Receiver R&D
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR C. B. Benham	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Golden, Colorado	FISCAL YEAR 1979 FUNDING $760,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $760,000

OBJECTIVE

The purpose of this contract is to develop receivers for high-temperature (> 600 ^{o}K) solar thermal applications. The applications currently being addressed include chemical processes, chemical heat pipes, and thermochemical storage reactions. Receiver concepts under development include catalytic, heat pipe, entrained solids, and hybrid receivers.

APPROACH

To achieve the project's objective, the contractor will identify promising receiver concepts, perform analyses and laboratory tests, design and fabricate receivers, and test these receivers on parabolic-dish concentrators at the Advanced Components Research (ACRES) facility.

STATUS

The following accomplishments have taken place thus far:

- The High-Temperature Applications Laboratory is operational. Preliminary tests have been performed in the laboratory on calcium hydroxide decomposition and biomass pyrolysis as part of the Entrained Solids Receiver development. A more versatile apparatus is being assembled in the laboratory to obtain heat transfer data on these systems for receiver design.

- Two 6-meter diameter parabolic dish concentrators have been installed at the ACRES facility and receiver efficiency tests have been performed on the first dish. These results were presented at the 1979 American Society of Mechanical Engineers/American Institute of Chemical Engineers (ASME/AIChE) Heat Transfer Conference.

- An advanced receiver using heat transfer coils imbedded in copper has been designed and is being fabricated for testing at the ACRES facility.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Heat Transfer and Receiver R&D
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR C. B. Benham	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Golden, Colorado	FISCAL YEAR 1979 FUNDING $760,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $760,000

(continued)

- o A laboratory-scale gravity return sodium heat pipe (thermosyphon) has been designed and is being fabricated for testing in the laboratory.

FUTURE EFFORTS

Additional receiver efficiency measurements will be made at the ACRES facility using a calorimetric technique to compare with results obtained by the Jet Propulsion Laboratory on a dish purchased from the same manufacturer (Omnium-G). The copper receiver will be tested on one of the dishes and flux maps will be made on both dishes. Laboratory tests will be conducted on both the thermosyphon receiver and entrained solids receiver. An entrained solids receiver will be fabricated and tested at the ACRES facility.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems F-7

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1536 Cole Boulevard Golden, Colorado 80401	Performance Testing and Test Facility
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR A. Lewandowski	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Golden, Colorado	FISCAL YEAR 1979 FUNDING $282,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $282,000

OBJECTIVE

The task objective is to develop, operate, and maintain a versatile test facility dedicated to the investigation of a variety of research issues relating to the thermal performance of concentrating solar collectors in the mid-temperature range.

APPROACH

Two primary activities are required for this task:

- Design, construct, and install the collection test facility (Mid-temperature Collector Facility).
- Prepare a draft procedure for thermal performance testing of concentrators as an input to the national consensus standard process.

The Mid-temperature Collector Research Facility (formerly STAM) will be capable of testing two collector modules simultaneously using various working fluids at flows up to 10 gallons/minute and temperatures to 650 ^{o}F. The instrumentation and data acquisition system includes state-of-the-art sensors, signal conditioning, and computation equipment.

The preparation of the draft standard is based upon an identification of critical issues and weaknesses of currently accepted procedures (ASHRAE 93-77). The draft is intended as a working document to be submitted to organizations with potential interest in generating a standard for thermal performance testing of concentrators. Such organizations include the American Society for Testing Materials (ASTM); the American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE); and the American Society of Mechanical Engineers (ASME).

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems

F-7

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1536 Cole Boulevard Golden, Colorado 80401	Performance Testing and Test Facility
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR A. Lewandowski	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Golden, Colorado	FISCAL YEAR 1979 FUNDING $282,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $282,000

(continued)

STATUS

A site plan including all SERI Interim Field Site activities is complete and construction was scheduled to begin in September 1979. The fluid loop portion of the Mid-temperature Collector Research Facility should be complete and ready for installation at the Interim Field Site by October 1979.

The draft standard has been submitted to American National Standards Institute (ANSI) for a determination as to whether ASTM, ASHRAE, or ASME should continue the standard writing activity in this case. The document has also been submitted for comment to commercial and government laboratories, university researchers, and concentrator manufacturers.

FUTURE EFFORTS

The following future activities are planned:

- Install and check-out the fluid loop, instrumentation, and data acquisition system for the Mid-temperature Collector Research Facility with the goal of making the facility operational by December 1979.
- Use of the facility when operational to investigate the identified concentrator performance issues associated with the draft standard procedures.
- In addition to the thermal performance standards, investigate other research issues, including measurement and calibration techniques, materials and fluids characterization, component development, and short- and long-term reliability studies.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems

F-8

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Heat Pipe Receiver Test Module
	CONTRACT NO. XP-9-8322-1
PRINCIPAL INVESTIGATOR W. B. Bienert	PERIOD OF PERFORMANCE September 30, 1979 to June 30, 1980
WORK LOCATION Dynatherm Corporation Marble Court off Industry Lane Cockeysville, Maryland 21030	FISCAL YEAR 1979 FUNDING $54,200
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $54,200

OBJECTIVE

The aim of this contract is to test a small heat pipe receiver module under actual flux conditions.

APPROACH

A heat pipe receiver module consisting of seven full-scale heat pipes will be designed and fabricated. The module will be configured in the same geometric pattern as a 30-MWth receiver developed by Dynatherm under a previous DOE contract (EY-76-C-02-2839). The module will be tested at the Advanced Components Test Facility (ACTF) at the Georgia Institute of Technology to evaluate the module performance over a range of temperatures and flux conditions.

STATUS

Work on this project was scheduled to begin on September 30, 1979.

Subcontractor: Dynatherm Corporation

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems F-9

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Operational Support for the Solar Thermal Test Facilities Users Association
	CONTRACT NO. SERI XD-8-0637-1 (formerly DOE EG-77-C-01-4042)
PRINCIPAL INVESTIGATOR F. B. Smith	**PERIOD OF PERFORMANCE** June 27, 1978 to September 30, 1979
WORK LOCATION STTFUA Albuquerque, New Mexico	**FISCAL YEAR 1979 FUNDING** $306,400
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	**CUMULATIVE FUNDING** $497,000

OBJECTIVE

The project goal is to provide support to the Solar Thermal Test Facilities Users Association (STTFUA) in disseminating information on, coordinating the use of, and arranging experiment funding for the Sandia Laboratories' 5-kWth Central Receiver Test Facility and the Georgia Institute of Technology's 400-kW Advanced Components Test Facility.

APPROACH

The University of Houston, the subcontractor on this contract, will assist the STTFUA by conducting the following activities:

- Acting as the point of contact for users of Solar Thermal Test Facilities (STTF's) and as a primary access link between users and operators of STTF's.
- Soliciting and reviewing proposals for experiments to be performed on STTF's and making recommendations regarding utilization on STTF's.
- Providing funding for STTF users, subject to SERI approval and funding availability.
- Disseminating STTF and experiment information on a regular basis.

STATUS

Three proposals received in FY 1978 were recommended for funding with FY 1979 funds. In addition, the Users Association (UA) announced the High-Temperature Solar Research Program to support testing at the STTF's and received thiry-six proposals in response. The proposals were evaluated and ranked, and ten were recommended for funding by the UA Executive Committee to SERI. Nine subcontracts are in the negotiation process and will be let by the end of FY 1979.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems F-9

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Operational Support for the Solar Thermal Test Facilities Users Association
	CONTRACT NO. SERI XD-8-0637-1 (formerly DOE EG-77-C-01-4042)
PRINCIPAL INVESTIGATOR F. B. Smith	PERIOD OF PERFORMANCE June 27, 1978 to September 30, 1979
WORK LOCATION STTFUA Albuquerque, New Mexico	FISCAL YEAR 1979 FUNDING $306,400
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $497,000

(continued)

FUTURE EFFORT

The contract with the University of Houston will be re-negotiated for FY 1980. Work has begun on another solicitation to be announced in FY 1980, in addition to organizing a workshop to emphasize STTF experiment opportunities in chemical and fuel technologies.

Subcontractor: University of Houston, Solar Energy Laboratory

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems F-1

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Advanced Solar Receivers High-Temperature Steam Loop Experiment
	CONTRACT NO. XP-9-8326-1
PRINCIPAL INVESTIGATOR P. B. Roberts	PERIOD OF PERFORMANCE September 30, 1979 to March 30, 1980
WORK LOCATION Solar Turbines International San Diego, California 92138	FISCAL YEAR 1979 FUNDING $50,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $50,000

OBJECTIVE

The purpose of this project is to investigate the use of high-temperature (1500 ^{o}F) steam systems for application to solar receivers.

APPROACH

A test solar receiver will be designed and fabricated for testing at the Advanced Components Test Facility at the Georgia Institute of Technology under differing flux conditions. The most significant parameters to be investigated are changes in the dryout zone position and circumferential tube wall variations. An effort will be made to correlate the empirical test results with output from existing software programs for the particular test geometry chosen.

STATUS

Work on this project was scheduled to begin on September 30, 1979.

Subcontractor: Solar Turbines International

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Subsystems F-11

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Devise and Test Program for a Fluidized Bed of Solid Particles as a Solar Thermal Receiver
	CONTRACT NO. XP-9-8321-1
PRINCIPAL INVESTIGATOR D. M. Bachovin	PERIOD OF PERFORMANCE September 30, 1979 to September 1, 1980
WORK LOCATION Westinghouse Electric Corp. Pittsburgh, Pennsylvania 15236	FISCAL YEAR 1979 FUNDING $66,800
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $66,800

OBJECTIVE

The project objective is to investigate application of fluidized bed technology to solar central receivers.

APPROACH

Potential commercial applications for the use of fluidized bed technology in solar central receivers will be reviewed and then two or more conceptual designs will be developed from the potential applications. The final concept will be selected and a design prepared to support fabrication of a test receiver. The receiver will be tested at the Central Receiver Test Facility (CRTF) in Albuquerque, New Mexico, to investigate the radiative properties of the fluidized particulate receiver system used in the design.

STATUS

This contract was in the negotiation stage as of September 1979.

Subcontractor: Westinghouse Electric Corporation, R&D Center

ADVANCED THERMAL TECHNOLOGY

G. Advanced Systems/Applications Project Summaries

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Systems/Applications G-1

CONTRACTOR/ADDRESS	TITLE
Energy Research and Generation, Inc. Powell and 55th Street Oakland, California 94606	Advanced Free-Piston Stirling Engine/ 15 kWe Linear Alternator Study
	CONTRACT NO. 955468
PRINCIPAL INVESTIGATOR G. Benson	PERIOD OF PERFORMANCE July 26, 1979 to December 22, 1979
WORK LOCATION Oakland, California	FISCAL YEAR 1979 FUNDING $125,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $125,000

OBJECTIVE

The purpose of this project is to perform the preliminary design and analysis of critical components and subassemblies of a 15-kWe Stirling engine with a linear alternator.

APPROACH

Existing Energy Research and Generation, Inc. computer programs will be used to determine thermodynamic, engine dynamic, gas bearing, and heat input/output characteristics for a 10-22 kW Stirling engine. In addition, linear alternator analysis and design will be performed.

STATUS

Preliminary design characteristics are being analyzed.

FUTURE EFFORT

A detailed design will be performed and a most promising configuration will be selected.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Systems/Applications G-2

CONTRACTOR/ADDRESS	TITLE
Fairchild Industries, Inc. Fairchild Stratos Division 1800 Rosecrans Avenue Manhattan Beach, California 90266	Design and Fabrication of the Dish-Stirling Solar Receiver
	CONTRACT NO. 955400
PRINCIPAL INVESTIGATOR R. Haglund	PERIOD OF PERFORMANCE March 1979 to November 1980
WORK LOCATION Manhattan Beach, California	FISCAL YEAR 1979 FUNDING $260,000
CONTRACTING OFFICE Jet Propulsion Laboratory Pasadena, California	CUMULATIVE FUNDING $260,000

OBJECTIVE

The objective of this contract is to demonstrate the technology for a minimum low-cost solar receiver, including fossil fuel hybrid operation, integrated with a Stirling-cycle engine-alternator.

APPROACH

A direct-coupled solar receiver is to be developed with the Stirling engine heat exchanger tubes embedded in a copper receiver body. A natural gas combustor is designed to heat the heater tubes convectively and radiatively from the back side of the receiver body. A Stirling engine is to be procured and integrated with the receiver, and tested for constant power operation.

STATUS

A Detailed Design Review was completed at the end of FY 1979. Decisions are pending in three primary areas: selection of a manufacturing process for the receiver body, selection of combustor control components, and verification of gas combustor parameters for final selection. The United Stirling P-40 engine was selected for procurement and will be modified for inverted operation.

FUTURE EFFORT

A gas combustor experiment is to be completed in October 1979, and controls will be finalized. Release of the design for fabrication is scheduled for November 1979. Fabrication will be completed for shipment of the receiver to United Stirling of Sweden for integration with the P-40 Stirling-cycle engine.

Subcontractors: Solar Turbines International; Georgia Institute of Technology; Institute of Gas Technology; United Stirling of Sweden

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Systems/Applications G-3

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Decomposition of Cadmium Oxide as a Step in Solar Thermochemical Hydrogen Production
	CONTRACT NO. XP-9-8325-1
PRINCIPAL INVESTIGATOR S. Foh	PERIOD OF PERFORMANCE September 30, 1979 to May 30, 1980
WORK LOCATION Institute of Gas Technology Chicago, Illinois	FISCAL YEAR 1979 FUNDING $78,500
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $78,500

OBJECTIVE

The purpose of this project is to quantify decomposition rate, temperature, and pressure of CdO in a solar-operated chemical reaction chamber.

APPROACH

A design for a silica reaction chamber will be prepared and two reactors will be fabricated. The contractor is to prepare kilogram quantities of CdO for test purposes and then analyze the decomposition of the material at reactor temperatures of 1000 ^{o}C to 1500 ^{o}C in tests to be performed at White Sands, New Mexico.

STATUS

This contract was approved by DOE and was awaiting contractor signature as of September 1979.

Subcontractor: Institute of Gas Technology

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Advanced Systems/Applications G

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Flash Pyrolysis of Biomass Using Concentrated Solar Radiation
	CONTRACT NO. XP-9-8324-1
PRINCIPAL INVESTIGATOR M. Antal	PERIOD OF PERFORMANCE September 30, 1979 to September 30, 1980
WORK LOCATION Princeton University Princeton, New Jersey 08540	FISCAL YEAR 1979 FUNDING $98,800
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $115,300

OBJECTIVE

The project objective is to develop hardware design and process kinetic information to support design of a prototype commercial unit.

APPROACH

A vortex flow reactor will be designed and fabricated for testing at the Advanced Component's Test Facility (ACTF) at the Georgia Institute of Technology. The reactor design will build on a previous test unit employed at Odeillo, France, using SERI/Solar Thermal Test Facilities Users Association funding. In addition, analytical tasks in pyrolysis kinetics and gas-phase reaction kinetics will be undertaken prior to and during reactor design to improve test unit design.

STATUS

This contract was awaiting DOE approval as of September 1979.

Subcontractor: Princeton University

ADVANCED THERMAL TECHNOLOGY

H. Supporting Programs
Project Summaries

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Supporting Programs

H-1

CONTRACTOR/ADDRESS	TITLE
Battelle Pacific Northwest Laboratories (BPNL) P. O. Box 999 Richland, Washington 99352	Research and Development for Solar Mirror Quality Assurance and Performance
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR M. A. Lind	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Richland, Washington	FISCAL YEAR 1979 FUNDING $275,000 (DOE supplied under BPNL prime contract)
CONTRACTING OFFICE DOE Operations Office Richland, Washington	CUMULATIVE FUNDING $675,000

OBJECTIVE

The goal of this project is fourfold:

- To support a viable data base on suitability and performance of materials used in solar reflectors.
- To develop new instrumentation and technologies to evaluate optical performance and stability of solar reflectors.
- To aid in developing new standards for mirror quality assurance.
- To increase communications in the solar reflector community.

APPROACH

Five tasks are required:

- Conduct a literature survey on optical materials used in solar reflectors.
- Procure, modify, assemble, and test optical measurements instrumentation.
- Work with the American Society for Testing Materials (ASTM) for development of standards.
- Coordinate with SERI in sponsoring an optical materials workshop for technology transfer.
- Conduct measurements for mirror figure and specularity for researchers.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Supporting Programs H-1

CONTRACTOR/ADDRESS	TITLE
Battelle Pacific Northwest Laboratories (BPNL) P. O. Box 999 Richland, Washington 99352	Research and Development for Solar Mirror Quality Assurance and Performance
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR M. A. Lind	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION Richland, Washington	FISCAL YEAR 1979 FUNDING $275,000 (DOE supplied under BPNL prime contract)
CONTRACTING OFFICE DOE Operations Office Richland, Washington	CUMULATIVE FUNDING $675,000

(continued)

STATUS

The following activities have been accomplished:

- o A Solar Material Technology Workshop has been held.
- o A spectrophotometer system and a krypton laser optics system have been procured.
- o An optics materials literature survey has been completed.
- o Several standards now in the approval process have been initiated.
- o Measurements have been and are being made for Dow Corning, General Electric, San Diego State College, and the National Bureau of Standards.

FUTURE EFFORT

Future activities include:

- o Releasing a report on completed work.
- o Continuing the testing of optical materials.
- o Coordinating a reflective materials workshop.
- o Completing installation and checkout of instrumentation.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Supporting Programs H-2

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Thermal Radiation Properties Measurements
	CONTRACT NO. XM-9-8714-1
PRINCIPAL INVESTIGATOR J. Richmond	PERIOD OF PERFORMANCE October 1, 1978 to September 30, 1979
WORK LOCATION National Bureau of Standards (NBS) Washington, D. C. 20234	FISCAL YEAR 1979 FUNDING $135,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $135,000

OBJECTIVE

This project has a twofold objective: (1) to select, procure, and calibrate standards of specular and directional hemispherical reflectance and (2) to establish NBS measurement capability for evaluating directional hemispherical reflectance at high temperatures and high-resolution bidirectional reflectance.

APPROACH

Four tasks are to be carried out under this contract:

- Precisely define wavelength distribution of solar radiation at various air-mass values.
- Evaluate spread of light beam caused by heliostat mirrors in photometric tunnel.
- Participate on the American Society for Testing Materials (ASTM) and other committees for definition and development of solar optical measurement standards.
- Develop optical standards to be sold as standard reference materials.

STATUS

Reflector standards are being developed for limited round robin analysis.

FUTURE EFFORT

e development of optical standards will be completed.

Subcontractor: National Bureau of Standards

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Supporting Programs

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Advanced Technology Program Management
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR B. P. Gupta	PERIOD OF PERFORMANCE June 1979 to September 1979
WORK LOCATION Golden, Colorado	FISCAL YEAR 1979 FUNDING $88,000
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $88,000

OBJECTIVE

The principal purpose of this contract is to completely decentralize the management of the DOE Solar Thermal Advanced Technology Program.

APPROACH

Tasks include planning, coordination, technical direction, review of progress, and issuance of contracts through normal mechanisms to industry, universities, and other laboratories.

STATUS

A program office has been set up within the Program Management Division at SERI to conduct the technical management of ongoing contracts and to coordinate the activity already underway at other laboratories. Initial activities undertaken are management of solar materials, the Advanced Components Test Facility (ACTF), and the Solar Thermal Test Facilities Users Association (STTFUA), as well as management and coordination of support activities such as Information Dissemination, and Quality Assurance and Standards Development.

FUTURE EFFORT

The overall responsibility for the entire program will be transferred to the SERI program office during FY 1980, beginning with the technical management of all contracts now underway and the initiation of new activities for FY 1980.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Supporting Programs H-4

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) Technology Commercialization Division 1617 Cole Boulevard Golden, Colorado 80401	Solar Thermal Technical Information Dissemination Project
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR M. Cotton	PERIOD OF PERFORMANCE October 1, 1978 to October 1, 1979
WORK LOCATION Golden, Colorado	FISCAL YEAR 1979 FUNDING $262,500
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $262,500

OBJECTIVE

The goal of this contract is twofold: to increase the volume and utility of technical information generated by the DOE solar thermal research and development (R&D) program and to create and make effective a program-wide communication network. This includes the establishment of channels of communication, the support of technology transfer activities underway at contractor locations, the collection of data for use by all programs, and the design and production of information packages which support the goals of early commercialization.

APPROACH

Tasks are grouped into four areas:

- The identification of load documents and the design of formats useable by four target audiences.
- The support of communication activities in progress at load laboratories.
- The establishment of monitoring and evaluation mechanisms within the user community to promote a two-way information flow which will aid commercialization of solar thermal technology.
- The creation of a data repository and reference/contact point for information dissemination which reflects SERI's mission as the national center for solar energy research.

ELEMENT: Advanced Thermal Technology

SUB-ELEMENT: Supporting Programs H-4

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) Technology Commercialization Division 1617 Cole Boulevard Golden, Colorado 80401	Solar Thermal Technical Information Dissemination Project
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR M. Cotton	PERIOD OF PERFORMANCE October 1, 1978 to October 1, 1979
WORK LOCATION Golden, Colorado	FISCAL YEAR 1979 FUNDING $262,500
CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $262,500

(continued)

STATUS

The DOE solar thermal power systems program collection of technical documents and visuals has been established at SERI in the Solar Energy Information Center. It consists of 1,000 technical reports or management summaries, 600 color slides, 125 8" x 10" color prints, assorted sound tracks and audio-visual materials, and a documents distribution service coordinated by the solar thermal Technical Information Dissemination (TID) project leader with the help of a subcontractor and Information Systems Division staff at SERI.

The FY 1978 Program Summary and the FY 1979 new contracts listing have been illustrated graphically and disseminated to commercialization audiences for both solar awareness and program element identification. Other printed materials taken from primary publications of the R&D program have been reformatted to fit the needs of nontechnical audiences and to encourage participation from potential users in the private sector.

Activities have been planned and implemented which actively involve representatives from universities, manufacturing, sciences, business, and media disciplines in the distribution, evaluation, and design of technical outreach programs for this technology. Market surveys, publications reviews, and conferences have supported this effort.

FUTURE EFFORT

FY 1980 strategies reflect the changing priorities of the R&D program as solar thermal power systems approach commercial readiness. Tasks include less solar awareness and more technical education emphases. Approximately one-third of TID funding is earmarked for support to industries, organizations, and demonstration projects across the program. One-third will be spent on the publication of comprehensive program documents--the Solar Thermal Power Technical Progress Report, a handbook for each program element, and summary co

CONTRACTOR/ADDRESS	TITLE
Solar Energy Research Institute (SERI) Technology Commercialization Division 1617 Cole Boulevard Golden, Colorado 80401	Solar Thermal Technical Information Dissemination Project
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PRINCIPAL INVESTIGATOR M. Cotton	PERIOD OF PERFORMANCE October 1, 1978 to October 1, 1979
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CONTRACTING OFFICE DOE/SERI Site Office Golden, Colorado	CUMULATIVE FUNDING $262,500

(continued)

and performance data. One-third will be subcontracted for data gathering, audience monitoring, and audio-visual production services which require unique skills and equipment unavailable among the SERI or contractor staffs. This includes the preparation of a technical course and at least one workshop for the American Society of Mechanical Engineers (ASME) Centennial. Additionally, specific projects in keeping with the SERI commercialization program goals will be initiated as the fiscal year unfolds.

BIBLIOGRAPHY

This bibliography lists reports and papers which have resulted from or are related to research projects described in this Program Summary. Unless otherwise specified, most of the reports can be obtained from:

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, Virginia 22161
(703) 557-4650

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- Establish an NTIS deposit account. Information can be obtained directly from NTIS at the Springfield, Virginia, address.

For further information contact:

DOE's Solar Thermal Power Systems Branch
Division of Central Solar Technology
600 E Street, N.W.
Washington, D. C. 20585
(202) 376-1934

BIBLIOGRAPHY

1. The project related to this publication is described in summary sheet A-1.

   "Low Cost Point Focus Concentrator - Phase I Final Report"
   Author: J. Vindum
   Date: March 1979

2. The project related to this publication is described in summary sheet A-4.

   "Low Cost Point Focus Concentrator - Phase I Final Report"
   Authors: D.K. Zimmerman, J. Laakso
   Date: March 1979

3. The project related to these publications is described in summary sheet B-3.

   "Field Survey of Solar Total Energy Systems Potential Industrial Application"
   Publication No. ORNL/Sub-7525/1*
   Date: December 1978

   "Solar Total Energy Systems (STES) Simulation Program Users' Guide"
   Publication No. ORNL/Sub-7525/2*
   Date: January 1979

   "STES Application Model (SAM) Users' Guide"
   Publication No. ORNL/Sub-7525/3*
   Date: January 1979

   "Market Penetration Model (MPM) Users' Guide"
   Publication No. ORNL/Sub-7525/4*
   Date: January 1979

   "Energy Division Annual Report"
   Publication No. ORNL-5513*
   Date: April 1979

   *Available through DOE's Oak Ridge National Laboratory, Oak Ridge, Tennessee.

4. The project related to this publication is described in summary sheet C-7.

   "Central Receiver Solar Thermal Power Systems: Collector Subsystem Extended Life Test"
   Publication No. DOE/ET-20424-1*
   Author: R. Gillette
   Date: May 1979

   *Available from Technical Information Center, Oak Ridge, Tennessee 37830

5. The project related to this publication is described in summary sheet C-13.

"Line Focus Solar Thermal Central Receiver Research Study"
Publication No. DOE/ET/20426-1
D. Decanio
Date: April 1979

6. The projects related to this publication is described in summary sheets C-16, C-17, C-19, C-20.

"Conceptual Design of Advanced Central Receiver Power Systems"
Publication No. SAN/20500 (Executive Summary plus five volumes) or DOE (ET/20314-1/1 and -1/2)
Date: June 1979

7. The project related to this publication is described in summary sheet C-18.

"Closed Brayton Cycle Advanced Central Receiver Solar Electric System"
Publication No. SAN 1726-1 (three volumes plus supplement)
Date: November 1978

8. The project related to this publication is described in summary sheet C-21.

"Heliostat Field Wind-Effects Test: Final Report"
Publication No. DOE/ET-20422-2
Date: February 1979

9. The project related to this publication is described in summary sheet C-22.

"Central Receiver Solar Thermal Power System, Phase I: Preliminary Design Report - Receiver Subsystem"
Publication No. SAN/1110-77-2
Author: D.N. Gorman
Date: April 1977

10. The project related to this publication is described in summary sheet C-23.

"Solar Central Receiver Hybrid Power System - Final Technical Report"
Publication No. DOE/ET/21038-1 (three volumes)
Author: C. N. Bolton
Date: September 1979

11. The project related to this publication is described in summary sheet C-25.

"Central Receiver Solar Thermal Power Systems: Pilot Plant Preliminary Design Report, Volume 4 - Receiver Subsystems"
Publication No. SAN/1108-8/4
Author: G.C. Coleman
Date: November 1977

12. The project related to this publication is described in summary sheet C-30.

"Conceptual Design of Advanced Central Receiver Power Systems - Sodium-cooled Receiver Concepts Final Report"
Publication No. SAN/1483-1/1 through 1/5
Author: T. Springer
Date: March 1979

13. The project related to this publication is described in summary sheet D-3.

"Heliostat Glass Survey & Analysis"
Authors: M.A. Lind and J. M. Rusin
Battelle Pacific Northwest Labs. Report No. BNL 2868
Date: September 1978

14. The project related to this publication is described in summary sheet D-13.

"Interim Structural Design Standard for Solar Energy Applications"
Author: A.C. Gangadharan
Sandia Labs, Report No. SAND 79-8183
Date: April 1979

15. The project related to this publication is described in summary sheet D-28.

"Non-Inverting Heliostat Study"
Author: J. Blackman
Sandia Labs, Report No. SAND 78-8190
Date: August 1979

16. The project related to this publication is described in summary sheet D-36.

"Receiver Tower Cost Study"
Author: W. Wang
Sandia Labs, Report No. SAND 78-8185*
Date: July 1979

*Available through the Solar Energy Research Institute/Technical Information Dissemination; Golden, Colorado

ALPHABETICAL INDEX
OF
CONTRACTORS

ALPHABETICAL INDEX OF FISCAL YEAR 1979 PRIME CONTRACTORS

for the

SOLAR THERMAL POWER SYSTEMS PROGRAM

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