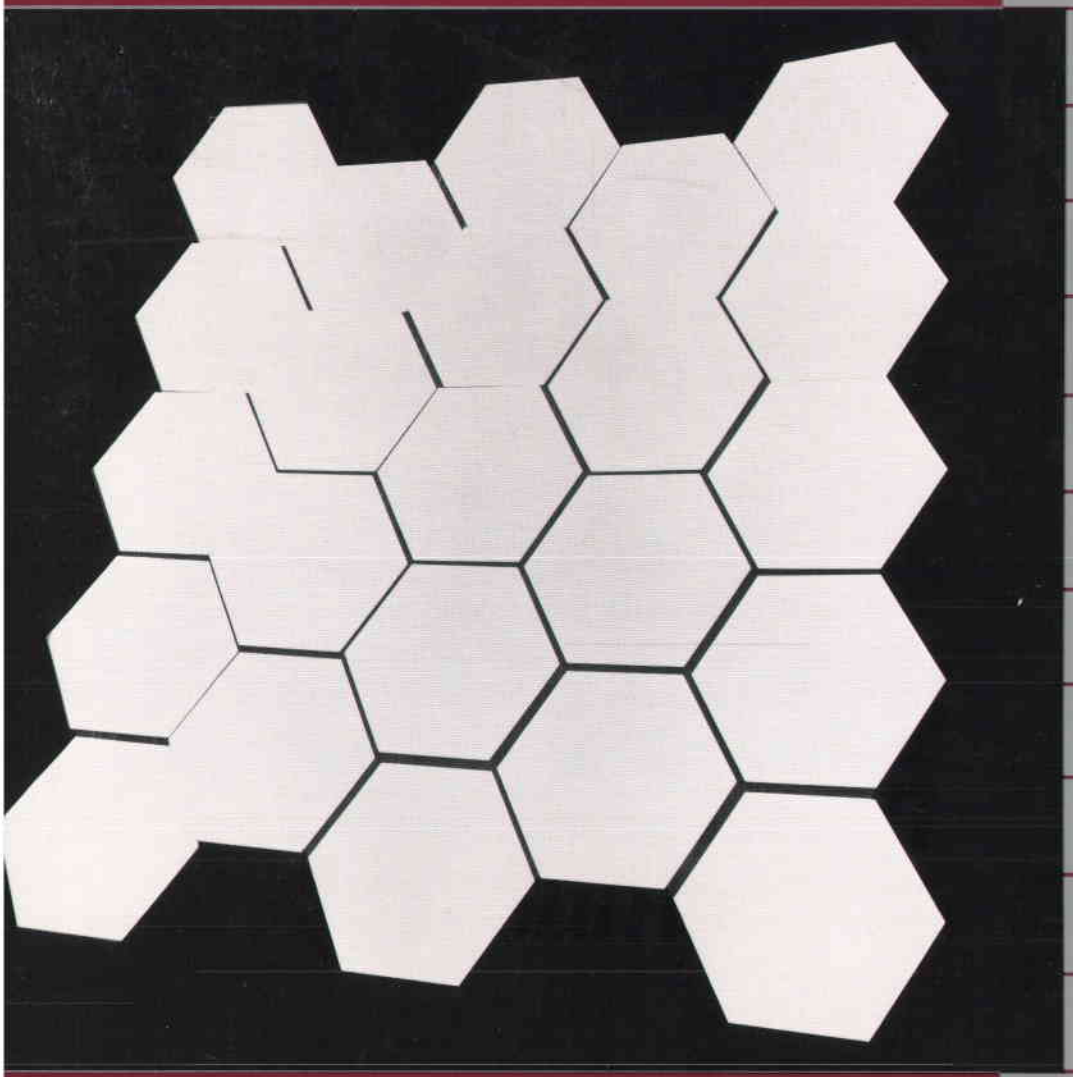

Programs in Renewable Energy

U.S. Department of Energy

Solar Thermal Program Summary

Volume II: Research Summaries

Fiscal Year 1989

On the cover: The primary concentrator at the SERI high-flux solar furnace has achieved a concentration ratio of more than 2000.

The Mission

The U.S. Department of Energy's Renewable Energy Program performs research and development in support of national policy goals for using renewable energy resources. As a part of the Renewable Energy Program, the mission of the Solar Thermal Technology Research Program is to develop concentrated solar energy as an economical, environmentally sound energy supply.

This publication is one of a series of documents on the Renewable Energy programs sponsored by the U.S. Department of Energy. An overview of all the programs is available, entitled *Programs in Renewable Energy*. In addition, FY 1989 Program Summary two-volume sets are available for each of the following programs:

Biofuels
Energy Storage and Distribution
Geothermal Energy
Ocean Energy
Photovoltaic Energy
Solar Buildings
Wind Energy.

For each program, *Volume I: Overview* contains a short overview of the program; *Volume II: Research Summaries* contains detailed descriptions of each research project. Copies of any of these documents may be obtained by writing:

Solar Energy Research Institute
Technical Inquiry Service
1617 Cole Boulevard
Golden, Colorado 80401-3393

PROGRAMS IN RENEWABLE ENERGY

Solar Thermal Program Summary

Volume II: Research Summaries

Fiscal Year 1989

U.S. Department of Energy

Prepared by the
Solar Technical Information Program
Solar Energy Research Institute
Golden, CO 80401-3393

DOE/CH10093-61
DE89009476
January 1990
UC Category: 234

Contents

Introduction

The federal government has conducted the national Solar Thermal Technology Program since 1975. Its purpose is to provide focus, direction, and funding for the development of solar thermal technology as an energy option for the United States.

More than a decade of research and development has brought solar thermal systems to a point where they have proven useful for generating electricity and process heat. Improvements to these during the 1980s led to reductions in capital and energy costs of 80%. Parabolic trough systems are now considered technically mature and are being used in the world's largest solar electric systems, generating electricity for less than $0.12/kWh. Central receiver and dish technologies have also been demonstrated in several plants throughout the world. The cost of concentrators, the largest cost component of solar thermal systems, has dropped from $900-$1300/m^2 in 1978 to $70-$160/m^2 today, while performance has improved significantly. Solar thermal technology has also shown strong potential for advanced applications, such as destroying hazardous wastes and processing materials and chemicals.

This annual summary provides an overview of the government-funded activities within the national Solar Thermal Technology Program. Tasks conducted in house by the participating national laboratories or under contract to industry and academic and other research institutions are highlighted. This document covers those activities initiated, renewed, or completed during FY 1989 (October 1, 1988, through September 30, 1989).

This summary is divided into two major sections. The first section includes the individual project descriptions for each activity grouped by directing organization. The second section provides a list of publications also grouped by directing organization. This list contains more complete bibliographic information than the individual contract descriptions.

For additional information on the national Solar Thermal Technology Program, refer to the *Solar Thermal Program Summary Fiscal Year 1989, Volume I: Overview; Focusing on the Future; Progress in Parabolic Dish Technology;* and *Central Receiver Technology: Status and Assessment.*

The first document summarizes this Program and provides further information on selected achievements during the past fiscal year as well as a breakdown of FY 1989 funding. The second document gives an overview of the Program's history, applications, research directions, and goals. The third document describes the current status of parabolic dish technology as well as the evolution of the technology and examples of projects in operation or under construction. The last of these documents describes central receiver technology: its accomplishments to date, its current technology status, and the efforts still necessary to fully exploit it. All four documents are available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia, 22161.

Organizational Relationships

The federal Solar Thermal Technology Program is conducted by the U.S. Department of Energy and is organizationally assigned to the assistant secretary for conservation and renewable energy. Day-to-day research activities are managed by the Solar Energy Research Institute in Golden, Colorado, and Sandia National Laboratories in Albuquerque, New Mexico.

FY 1989 Contract Descriptions

Sandia National Laboratories

Direct Absorption Receivers (DARs)
Panel Research Experiment (PRE) Absorber Panel Module Design

Project/Area/Task:
Central Receiver Technology/Receivers

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. M. Chavez

Telephone: (505) 844-4485

Contractor:
Babcock & Wilcox
20 S. Van Buren Ave.
Barberton, Ohio 44203

Principal Investigator: J. P. Reed

Contract Number: SNL 63-3991

Contract Period: 09/87 – 09/89

Contract Funding (Source):
FY 1987: -0- (---)
FY 1988: $60,608 (DOE)
FY 1989: -0- (DOE)

Objectives:

To design a DAR absorber panel for use on the DAR PRE that is being conducted at Sandia National Laboratories. The contractor will provide fabrication drawings and participate in the test data analysis of the panel design.

Approach/Background:

To allow flow testing with molten nitrate salt and provide a test bed for DAR testing, a 3-MW_t solar PRE was designed and is being constructed. Thermal analysis was performed previously to evaluate the DAR absorber panel requirements. This thermal analysis will be utilized by the contractor to design an absorber surface to meet the PRE test objectives. After the testing begins, the contractor will participate in the testing to evaluate the absorber panel performance.

Status/Accomplishments:

The contractor has completed the originally agreed to absorber panel design. Drawings and computer-aided design files have been received by Sandia. A final report is in progress.

Major Project Reports:

Letter report issued by Babcock & Wilcox to Sandia National Laboratories. This letter report, *Panel and Frame Design for the Direct Absorption Receiver Panel Research Experiment*, will be included as an appendix in the PRE final report.

Summary Report: October 1989

Molten Salt Subsystem/Component Test Experiment (MSS/CTE)

Project/Area/Task:
Central Receiver Technology/Receivers

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. M. Chavez

Telephone: (505) 844-4485

Contractor:
Babcock & Wilcox
P.O. Box 835
Alliance, Ohio 44601

Principal Investigator: B. D. Young

Telephone: (216) 860-6270

Contract Number: SNL 91-4687

Contract Period: 03/84 – 10/89

Contract Funding (Source):
FY 1984: $704,922 (DOE)
FY 1985: $1,845,078 (Participants)
FY 1986: $2,202,658 (DOE)
FY 1986: $329,948 (Participants)
FY 1987: $2,438,332 (DOE)
FY 1987: $353,118 (Participants)
FY 1988: $225,901 (DOE)
FY 1988: $85,278 (Participants)
FY 1989: $12,000 (DOE)

Objectives:

To resolve the present technical uncertainties of solar central receiver molten salt subsystems and components. Also, to provide a sound technological base for development of a molten salt industry. Finally, to support the design and construction plans for advanced commercial central receiver plants.

Approach/Background:

The MSS/CTE is a hardware development and test program being conducted at the Central Receiver Test Facility (CRTF). The project, managed by Sandia National Laboratories with Babcock & Wilcox as the prime contractor, is cost shared by DOE and six contractors. An advanced 5-MW_t cavity receiver was built and tested at the CRTF. In addition, full-sized (for use in a 30-MW_e central receiver plant) hot and cold molten salt pumps and valves were assembled into test loops to simulate commercial plant operations.

Status/Accomplishments:

The first phase of receiver characterization testing was completed in FY 1987. The testing confirmed the receiver design. Receiver efficiency was found to be on the order of 90%, with the receiver tested at a nominal power of 4.5 MW_t. A second phase of receiver testing was completed in early FY 1988 and provided additional data and confirmed the results of the first phase of testing. Once testing was completed, the receiver was removed from the top of the CRTF tower.

Both the hot and cold pump and valve loops were assembled and tested. The hot loop has achieved over 2400 hours of operation. Although we initially experienced problems with the valve packing materials, two new candidate packing materials have given over 1000 hours of service without leaking. They did not have any problems for as many as 2400 hours of operation. In general, the hot loop has been operating satisfactorily. However, because of pump problems (manufacturer design problem) on the cold loop, only limited test time has been attained. The hot loop is currently being tested and has approximately 400 hours of testing. The cold loop has less than 6 hours of test time and is awaiting repair of the motor.

Major Project Reports:

Kolb, G. J., D. Neary, M. R. Ringham, and T. L. Greenlee, *Dynamic Simulation of a Molten-Salt Solar Receiver.*

Rush, E. E., C. W. Matthews, and J. M. Chavez, *An Interim Report on the Testing of the Molten Salt Pump and Valve Loops.*

Smith, D. C., and J. M. Chavez, *A Final Report on the Phase I Testing of a Molten-Salt Cavity Receiver--Volume I: A Summary Report.*

Smith, D. C., and J. M. Chavez, *A Final Report on the Phase I Testing of a Molten-Salt Cavity Receiver--Volume II: The Main Report.*

Summary Date: October 1989

Contract Engineering Design Services

Project/Area/Task:
Central Receiver Technology/Distributed Receiver Technology

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: C. P. Cameron

Telephone: (505) 844-0363

Contractor:
Black & Veatch
P.O. Box 8405
Kansas City, MO 64114

Principal Investigator: B. Blesser

Telephone: (913) 339-2000

Contract Number: SNL 33-1900

Contract Period: 02/87 – 12/89

Contract Funding (Source):
FY 1987: $200,000 (DOE)
FY 1988: -0- (---)
FY 1989: $10,000 (DOE)

Major Project Reports: None

Summary Date: October 1989

Objective:

To provide engineering design services for National Solar Thermal Test Facility modifications and upgrades to satisfy central and distributed receiver test programs. Documentation of services rendered varies with the issue being addressed.

Approach/Background:

Services provided include mechanical engineering, electrical engineering, civil engineering, and design drafting services on an as-needed basis to satisfy testing programs.

Status/Accomplishments:

Performed structural review for Direct Absorption Receiver Project. Designed blast-resistant window frame for Engine Test Facility.

Catalytically Enhanced Solar Absorption Receiver (CAESAR) Experiment

Project/Area/Task:
High-Temperature Solar Destruction of Hazardous Wastes/Toxic Chemicals

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. M. Muir

Telephone: (505) 846-7818

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: J. M. Muir

Telephone: (505) 846-7818

Contract Number: DE-AC04-76-DP00789

Current Contract: 10/88 – 09/89

Contract Funding (Source):
FY 1989: $285,000 (DOE)

Objective:

To provide a commercial-scale demonstration of CO_2 reforming of methane in a 100-kW direct catalytic absorption receiver (DCAR) mounted on Deutsche Forschung Anstalt fur Luft- and Raumfahrt's (DLR's) 17-m dish at the PAN facility near Lampoldshausen, Federal Republic of Germany (FRG).

Approach/Background:

The CAESAR experiment is a joint U.S./FRG activity, under Task V of the International Energy Agency/Small Solar Power Systems (IEA/SSPS) project, involving Sandia and the DLR-Stuttgart. DLR provided the receiver and test facility, and Sandia provided the catalytic absorber for the DCAR, the gas handling equipment, and the analysis train. Personnel from both laboratories are participating in the planning, testing, modeling, evaluation, and documentation phases of the project. Tests are being conducted to determine the thermal, chemical, and mechanical performance of CAESAR over a wide range of operating conditions (power, temperature, and CO_2/CH_4 ratio).

Status/Accomplishments:

Sandia designed and fabricated the gas supply, analysis, and calibration systems and shipped them to DLR.

We also fabricated two multilayered, porous alumina DCAR absorber disks, 64 cm in diameter by 5 cm thick: One allows a uniform gas flow over its surface, and the other is designed for a nonuniform gas flow that approximates the solar flux distribution (higher in the center and lower toward the outside of the disk). Both disks were loaded with rhodium catalyst to approximately 0.2% by weight and shipped to DLR.

The CAESAR unit containing the uniform-flow absorber was mounted on the Paraboloid Testanlage (PAN) dish and tested in both thermal and chemical (reforming) modes. Preliminary results indicate that CAESAR performed satisfactorily over a range of operating conditions, steady-state and transient, in both thermal and reforming modes. The most severe limitation on performance appears to be the peaked solar flux distribution. This will be explored further during tests with the nonuniform-flow absorber in early FY 1990.

DCAR computer models were developed and used for CAESAR predictions at both Sandia and DLR.

Major Project Reports:

Final report scheduled for mid-1990.

Summary Date: October 1989

Economic Evaluation of Materials Processing Using a Solar Furnace

Project/Area/Task:
Materials Processing

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: G. J. Kolb

Telephone: (505) 846-1976

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: G. J. Kolb

Telephone: (505) 846-1976

Contract Number: DE-AC04-76-DP00789

Contract Period: 10/88 – 09/89

Contract Funding (Source):
FY 1989: $25,000 (DOE)

Objective:

To compare the economics of materials processing with solar energy with comparable nonsolar processing techniques.

Approach/Background:

Several types of materials are capable of being processed by concentrated solar energy. For example, small-scale experiments have demonstrated the feasibility of (1) surface treatment of carbon fibers; (2) growth of ceramic whiskers by chemical vapor deposition; (3) powder coating of metals; and (4) transformation hardening of steels. All these materials were processed in a high-flux solar furnace (i.e., >3000 suns). It is feasible that these materials could have been processed by high-intensity arc lamps employing xenon or argon because the flux levels and energy spectrum are similar to those found in the solar furnace. These lamps are commercially available and are finding increased use within the materials processing industry. In this analysis, the economics of processing with arc lamps is compared with solar furnace processing.

Status/Accomplishments:

The comparative analysis indicated that the solar furnace can be more cost effective than the arc lamp system by as much as a factor of three under certain operating scenarios. In other scenarios, the lamp is more cost effective. The scenario that appears to be most promising for the furnace is batch processing that employs flux levels >5000 suns.

Major Project Reports:

A major report, conference paper, or both will be written at a future date.

Summary Date: October 1989

Direct Absorption Receiver (DAR) Research and Development (R&D)

Project/Area/Task:
Central Receiver Technology/Receivers

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. M. Chavez

Telephone: (505) 844-4485

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: J. M. Chavez

Telephone: (505) 844-4485

Contract Number: DE-AC04-76-DP00789

Contract Period: 05/86 – 05/90

Contract Funding (Source):
FY 1986: $300,000 (DOE)
FY 1987: $1,250,000 (DOE)
FY 1988: $1,600,000 (DOE)
FY 1989: $900,000 (DOE)

Objectives:

To perform R&D necessary to complete a concept evaluation and conduct a system test of the DAR.

Approach/Background:

A joint Sandia/SERI R&D program has been under way for three years to determine the feasibility of the DAR concept. In a DAR, the heat-absorbing fluid (a blackened molten nitrate salt) flows in a thin film down a flat, near-vertical panel (rather than through tubes) and absorbs the concentrated solar flux directly. Potential advantages of the DAR include a significantly simplified design, improved thermal performance, increased reliability and operating life, and reduced capital and operating costs. The DAR has the potential to meet the long-term DOE cost goals for solar central receiver plants. A number of technological uncertainties affecting DAR feasibility require resolution before the concept can be considered a commercial alternative.

Status/Accomplishments:

The systems studies of the DAR have shown that the DAR has the potential to reduce the levelized energy cost by 26% over salt-in-tube receivers in the long term. The work conducted to date has involved system studies, materials research, small-scale panel tests with water and molten salt, and large-scale tests with water and salt. To allow flow testing with molten nitrate salt and provide a test bed for DAR testing in an actual solar environment, a 3-MW_t salt flow loop was designed and is being constructed. This culminating test is called the Panel Research Experiment (PRE). In this experiment, a 3-MW_t solar test of the DAR will be conducted at the Central Receiver Test Facility at Sandia to demonstrate and evaluate the performance of the DAR.

Three areas of the DAR design and development were contracted out. An external DAR design study was conducted by Foster Wheeler Solar Development Corporation to evaluate the feasibility and costs of an external commercial DAR on a systems level. Advanced Thermal Systems performed the design and layout of the PRE structure and piping and is consulting on the fabrication of the PRE. Finally, Babcock & Wilcox Corporation has completed a preliminary design of the DAR absorber panel fo the PRE.

It has not been possible to resolve all the technical uncertainties of the DAR concept with the water flow testing and small-scale salt testing conducted thus far. However, based on this testing, the DAR concept appears to be feasible and promising. The PRE test will determine the feasibility and performance of the DAR. The construction and fabrication of the PRE is currently 90% complete.

Major Project Reports:

Wu, S. F., and T. V. Narayana, *Commercial Direct Absorption Receiver Design Studies--Final Report.*

Tyner, C. E., *Status of the DAR Panel Research Experiment: Salt Flow and Solar Test Requirements and Plans.*

Chavez, J. M., D. K. Johnson, C. E. Tyner, and W. A. Couch, *Water Flow Testing of the Direct Absorption Receiver Concept.*

Summary Date: October 1989

Development of a Control System for a Direct Absorption Central Receiver

Project/Area/Task:
Central Receiver Technology

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: G. J. Kolb

Telephone: (505) 846-1976

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: G. J. Kolb

Telephone: (505) 846-1976

Contract Number: DE-AC04-76-DP00789

Contract Period: 10/86 – 09/89

Contract Funding (Source):
FY 1987: $10,000 (DOE)
FY 1988: $30,000 (DOE)
FY 1989: $25,000 (DOE)

Objective:

To develop control algorithms for experimental-scale and commercial-scale direct absorption receivers (DARs).

Approach/Background:

DARs have the potential for several design advantages over salt-in-tube receivers. One such advantage--and the focus of this investigation--is ease of receiver control. To demonstrate this advantage, control algorithms were developed for the DAR to be tested during the upcoming Panel Research Experiment (PRE) and a hypothetical commercial-scale receiver. The algorithms were developed with the aid of computer models that simulate the dynamics of the receiver. The complexity of the control algorithms was compared with that required by salt-in-tube receivers.

Status/Accomplishments:

The simulation model and control algorithm for the PRE were expanded to include the entire flow loop, i.e., receiver, pump, heat exchanger, etc. This expanded model will help characterize the performance of the DAR during the experiment. A user-friendly graphics display was developed to facilitate understanding of the process dynamics by project personnel and visitors from government and industry.

Major Project Reports:

A conference paper was written (see below). A major report will be written after the conclusion of the PRE.

Kolb, G. J., D. Neary, and M. R. Ringham, *Demonstration of PC-Based Dynamic Simulation Models of Solar Thermal Systems.*

Summary Date: October 1989

Contract Engineering Design Services

Project/Area/Task:
Central Receiver Technology/Distributed Receiver Technology

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: C. P. Cameron

Telephone: (505) 844-0363

Contractor:
Black & Veatch
P.O. Box 8405
Kansas City, MO 64114

Principal Investigator: B. Blesser

Telephone: (913) 339-2000

Contract Number: SNL 33-1900

Contract Period: 02/87 – 12/89

Contract Funding (Source):
FY 1987: $200,000 (DOE)
FY 1988: -0- (---)
FY 1989: $10,000 (DOE)

Major Project Reports: None

Summary Date: October 1989

Objective:

To provide engineering design services for National Solar Thermal Test Facility modifications and upgrades to satisfy central and distributed receiver test programs. Documentation of services rendered varies with the issue being addressed.

Approach/Background:

Services provided include mechanical engineering, electrical engineering, civil engineering, and design drafting services on an as-needed basis to satisfy testing programs.

Status/Accomplishments:

Performed structural review for Direct Absorption Receiver Project. Designed blast-resistant window frame for Engine Test Facility.

Test Support Personnel

Project/Area/Task:
Distributed Receiver Technology/Distributed Receiver Systems

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: K. S. Rawlinson

Telephone: (505) 844-2178

Contractor:
EG&G Special Projects
2450 Alamo Avenue, SE
Albuquerque, NM 87106

Principal Investigator: V. Dudley

Telephone: (505) 846-5483

Contract Number: SNL 05-4912

Contract Period: 12/88 – 10/93

Contract Funding (Source):
FY 1989: $150,000 (DOE)

Objective:

To provide engineering and technical support to the test activities at the Distributed Receiver Test Facility (DRTF).

Approach/Background:

One test engineer and one technician, each with several years of experience in the solar thermal program, support test activities under the direction of the Sandia staff members on site at the DRTF.

Status/Accomplishments:

The test engineer performed software development, data analysis, and testing for the solar detoxification, Stirling heat engine, and sodium heat-pipe receiver projects. The technician performed mechanical and electrical fabrication and operation in support of the same projects.

Major Project Reports: None

Summary Date: October 1989

Test Support Personnel

Project/Area/Task:
Distributed Receiver Technology/Distributed Receiver Systems

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: C. P. Cameron

Telephone: (505) 844-0363

Contractor:
EG&G Washington Analytic
2450 Alamo Avenue, SE
Albuquerque, NM 87106

Principal Investigator: V. Dudley

Telephone: (505) 846-5483

Contract Number: SNL 52-5653

Contract Period: 08/83 – 11/88

Contract Funding (Source):
FY 1983: $150,000 (DOE)
FY 1984: -0- (---)
FY 1985: $100,000 (DOE)
FY 1986: $200,000 (DOE)
FY 1987: $100,000 (DOE)
FY 1988: $ 40,000 (DOE)
FY 1989: $150,000 (DOE)

Objective:

To provide engineering and technical support to the test activities at the Distributed Receiver Test Facility (DRTF).

Approach/Background:

One test engineer and one technician, each with several years of experience in the solar thermal program, support test activities under the direction of the Sandia staff members on site at the DRTF.

Status/Accomplishments:

The test engineer performed software development, data analysis, and testing for the solar detoxification, Stirling heat engine, and sodium heat-pipe receiver projects. The technician performed mechanical and electrical fabrication and operation in support of the same projects.

Major Project Reports: None

Summary Date: October 1989

Dynamic Simulation of Salt-in-Tube Central Receivers

Project/Area/Task:
Central Receiver Technology

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: G. J. Kolb

Telephone: (505) 846-1976

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

ESSCOR Corporation
512 Via de la Valle, Suite 311
Solana Beach, CA 92075

Principal Investigator: G. J. Kolb

Telephone: (505) 846-1976

Contract Number: 53-4209 (ESSCOR)

Contract Period: 05/86 – 03/89

Contract Funding (Source):
FY 1986: $91,000 (DOE)
FY 1987: $84,500 (DOE)
FY 1988: $30,000 (DOE)
FY 1989: $20,000 (DOE)

Objective:

To develop a PC-based simulation model of a salt-in-tube solar central receiver plant to support the development of a commercial-scale system.

Approach/Background:

The U.S. utility industry has expressed interest in developing a commercial-scale central receiver system using molten salt as the working fluid. Industry members participated in the development of an experimental-scale receiver tested at the Central Receiver Test Facility in 1987 and recently completed a study to define the next-generation central receiver plant. Dynamic simulation models can be used to improve the design and operation of these plants. In particular, they can be used to (1) optimize control algorithms, (2) define margins of safety by studying the system response to equipment failures, and (3) optimize energy production.

In this project, a simulation model was developed that mimicked the experimental-scale receiver. The model is user friendly and runs on an IBM PC. This effort promotes technology transfer between Sandia and the utility industry.

Status/Accomplishments:

The simulation model was completed and validated with experimental data. The model was shown to accurately predict the actual receiver performance during various transient conditions. The accuracy of the prediction helped resolve an uncertain issue regarding performance prediction that was identified by the DOE utility studies. The accuracy also ensures that the model will be useful in performing design improvement studies for the next-generation salt-in-tube receiver. Copies of the user's manual and computer software were disseminated to several utilities and architect engineering firms interested in central receiver technology. The final report for the project was published in March 1989.

Major Project Reports:

Neary, D. T., and M. R. Ringham, *A Dynamic Simulator/Analyzer for the Central Receiver Test Facility (User's Manual).*

Kolb, G. J., D. Neary, M. R. Ringham, and T. L. Greenlee, *Dynamic Simulation of a Molten-Salt Solar Receiver.*

Summary Date: October 1989

Contract Technicians

Project/Area/Task:
Central Receiver Technology/Central Receiver Test Facility

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: E. E. Rush

Telephone: (505) 844-5579

Contractor:
Ewing Technical Design, Inc.
630 Haines, NW
Albuquerque, NM 87102

Principal Investigator: M. Guggino

Telephone: (505) 243-6776

Contract Number: SNL 63-5487

Contract Period: 04/89 – 04/92

Contract Funding (Source):
FY 1988: $380,000 (DOE)
FY 1989: $387,000 (DOE)

Objective:

To assist in the assembly, operation, and maintenance of facilities and experiments at the National Solar Thermal Test Facility (NSTTF).

Approach/Background:

The NSTTF includes five major facilities for performing solar thermal experiments: the Central Receiver Test Facility (CRTF), the Distributed Receiver Test Facility (DRTF), the Solar Furnace, the Line Focus Facility, and the Engine Test Facility (ETF). Assembly, operation, and maintenance of NSTTF facilities and experiments is performed by Sandia personnel with the assistance of contract technicians. This contract provides for a maximum of 12 technicians on an as-needed basis. During FY 1989, the average manpower level on this contract was five mechanical, three electronic, and one computer technician.

Status/Accomplishments:

Satisfying the basic objective, the technicians on this contract operated and maintained the NSTTF facilities during FY 1989. In addition, the technicians assisted in the assembly, checkout, and testing of a number of experiments performed at the complex in the following areas: molten salt direct absorption receiver, molten salt pump and valve, prototype heliostat, organic Rankine engine, and the new CRTF field control and data-acquisition systems.

Major Project Reports: None

Summary Date: October 1989

Direct Absorption Receivers (DARs) Design Studies

Project/Area/Task:
Central Receiver Technology/Central Receivers

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. M. Chavez

Telephone: (505) 844-4485

Contractor:
Foster Wheeler Solar Development Corporation
12 Peach Tree Hill Road
Livingston, NJ 07039

Principal Investigator: S. F. Wu

Telephone: (201) 535-2327

Contract Number: SNL 06-0312

Contract Period: 09/87 – 03/90

Contract Funding (Source):
FY 1987: $121,000 (DOE)
FY 1988: $ 15,884 (DOE)
FY 1989: -0- (---)

Objectives:

To investigate potential external DAR commercial designs, including panel and support system design, distribution and collection manifold design and thermal/hydraulic performance, blackener performance and costs, instrumentation and control requirements, and costs relative to salt-in-tube receivers.

Approach/Background:

In a DAR, the heat-absorbing fluid (a blackened molten nitrate salt) flows in a thin film down a flat, near-vertical panel (rather than through tubes) and absorbs the concentrated solar flux directly. Potential advantages of the DAR include a significantly simplified design, improved thermal performance, increased reliability and operating life, and reduced capital and operating costs. To investigate the potential advantages of the DAR, the following tasks needed to be performed: (1) evaluate effects of receiver geometries and materials on thermal stress and panel deformations, (2) assess response and hydraulic performance of manifold and piping, (3) develop receiver conceptual design, and (4) estimate costs relative to salt-in-tube receivers developed for the Central Receiver Utility Studies.

Status/Accomplishments:

The thermal stress analyses of the primary panel alternatives were completed in 1987. The conceptual design and cost estimates were completed in 1988. The final report was completed and published.

Major Project Reports:

Wu, S. F., and T. V. Narayana, *Commercial Direct Absorption Receiver Design Studies--Final Report.*

Summary Date: October 1989

Solar Total Energy Project (STEP) Test Program

Project/Area/Task:
Distributed Receiver Technology/Shenandoah

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: A. A. Heckes

Telephone: (505) 844-3918

Contractor:
Georgia Power Company
7 Solar Circle
Shenandoah, GA 30265

Principal Investigator: E. J. Ney

Telephone: (404) 253-0218

Contract Number: SNL 42-4859

Current Contract: 06/89 - 06/90

Contract Funding (Source):
FY 1989: $42,000 (DOE)

Objective:

To determine field performance and reliability of the new fiber optic control system installed in FY 1988 and to monitor the STEP plant performance. The goal is to integrate the new Foxboro Balance of Plant (BOP) Control System with the fiber optic solar field controls. The Foxboro BOP controls incorporate a state-of-the-art expert optimizing system that uses artificial intelligence to improve the heat rate of the steam turbine/electrical generator and that automates and optimizes the electrical energy output of the plant. The test program will be successful if a larger fraction of the solar energy is converted to electricity.

Approach/Background:

Performance of the Shenandoah Plant will be monitored during the installation of the Foxboro Expert Optimizing System and during the two 15-day operational tests in fall 1989.

Status/Accomplishments:

The Foxboro Expert Optimizing System was installed and checked out. Preliminary testing was done. Results to date are very encouraging.

FY 1990 Milestones:

November 1989--Conduct the 15-day tests.

January 1990--Prepare test reports.

Major Project Reports:

At least one conference paper and one Sandia document are planned for FY 1990.

Summary Date: October 1989

Improvement of the Oxidation Resistance of Carbon Fibers

Project/Area/Task:
Materials Processing

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: G. J. Kolb

Telephone: (505) 846-1976

Contractor:
Georgia Tech Research Corporation
Georgia Institute of Technology
Atlanta, GA 30332

Principal Investigator: J. Shutt

Telephone: (404) 894-3678

Contract Number: SNL 40-2672

Contract Period: 5/89 - 5/91

Contract Funding (Source):
FY 1989: $80,000 (DOE)

Objective:

To develop a solar processing technique to produce carbon fibers with improved oxidation resistance of carbon fibers.

Approach/Background:

Carbon-fiber-reinforced-carbon composites consist of synthetic pure elemental carbon. Carbon-carbon composites are a high-tech material containing many ideal properties; their primary market is aerospace.

These composites, however, do suffer one major disadvantage. When exposed to an oxygen environment and to temperatures greater than 400°C, carbon readily oxidizes to form gaseous carbon oxides. Intensive research is currently being performed in the western world to improve the oxidation resistance of carbon-carbon composites.

The effort at Georgia Tech is focused on improving the oxidation resistance of the reinforcing fibers. Preliminary results indicate that treatment of the fibers with hyperthermal fluxes of concentrated solar radiation can dramatically increase the oxidation resistance of the fibers.

Status/Accomplishments:

The contract with Georgia Tech was established late in the fiscal year. Since that time, Georgia Tech has developed a conceptual design for an apparatus to handle the carbon fibers within its solar furnace. This apparatus should greatly facilitate the carbon fiber treatment process.

Major Project Reports:

On completion of the work, a report will be issued, and a paper will be submitted to a major materials processing journal.

Summary Date: October 1989

Heliostat Development

Project/Area/Task:
Heliostats

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185-5800

Project Managers: D. J. Alpert, J. W. Grossman, R. M. Houser, A. A. Heckes

Telephone: (505) 844-6982, (505) 846-5482, (505) 846-8107, (505) 844-3918

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185-5800

Principal Investigators: C. E. Tyner, J. T. Holmes, B. W. Marshall

Telephone: (505) 844-3340, (505) 844-2280, (505) 844-2964

Contract Number: DE-AC04-76-DP00789

Contract Period: 12/88 – 09/89

Contract Funding (Source):

	Internal	Contracts	
FY 1987:	$750,000	$1,150,000	(DOE)
FY 1988:	$680,000	$ 700,000	(DOE)
FY 1989:	$450,000	$ 800,000	(DOE)

Objective:

To establish commercial readiness of heliostats for central receiver solar thermal applications.

Approach/Background:

Commercial readiness of the technology will be established when sufficient industrial manufacturing and in-field operating experience exists so industry can confidently respond to market opportunities without government support. Concepts for improved heliostat components, conceived at Sandia and SERI, are transferred to private industry for development into marketable products. Current development activities are directed in four areas: (1) large-area heliostats that can be produced for lower costs because of economies of scale; (2) an innovative heliostat design, called the stretched-membrane heliostat, that is simpler and lighter in weight than the glass-mirror designs; (3) low-cost heliostat drives; and (4) cost-effective approaches to heliostat cleaning and membrane replacement. Contracts with private industry, described elsewhere, were issued for the design and fabrication of prototype heliostats and low-cost heliostat drives. These are tested and evaluated at Sandia to demonstrate operation, gain operating experience, verify performance and durability, and identify possible improvements.

Status/Accomplishments:

Optical evaluation of the two large-area glass-mirror heliostats was not completed as planned. The drive on the 200-m^2 heliostat was repaired but later failed during a qualification test under static loads. The drive on the 150-m^2 heliostat, which had worked well, was replaced with a prototype of the new low-cost drive. The new drive performed to standards but was damaged by water that collected inside and froze. The drive was modified by the manufacturer, and testing was resumed.

Two improved designs for commercial-scale stretched-membrane heliostats were developed. Fifty-square-meter prototype mirror modules, representative of the improved designs, were fabricated and installed at the Solar Thermal Test Facility for evaluation by Sandia. Preliminary results show the improved designs perform significantly better than the first-generation designs, especially in windy conditions. The design of fully integrated, market-ready heliostats began, and one design was completed.

Major Project Reports:

Alpert, D. J., D. K. Johnson, R. M. Houser, L. Yellowhorse, and J. VanDerGeest, *Optical Performance of the First Prototype Stretched-Membrane Mirror Modules.*

Development of a Low-Cost Drive Tracking Mechanism for Solar-Heliostats or PV Arrays, Peerless-Winsmith, Inc.

Summary Date: October 1989

Innovative Point-Focus Solar Concentrator

Project/Area/Task:
Parabolic Dishes/Evaluation of the LaJet Innovative Concentrator

Directing Organization:
Albuquerque Operations Office
U.S. Department of Energy
P.O. Box 5400
Albuquerque, NM 87115

Project Manager: T. R. Mancini

Telephone: (505) 844-8643

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: T. R. Mancini

Telephone: (505) 844-8643

Contract Number: DE-AC04-76-DP00789

Contract Period: 10/88 – 09/89

Contract Funding (Source):
FY 1989: $100,000 (DOE)

Objective:

To repair and test the LaJet Innovative Concentrator.

Approach/Background:

The LaJet Energy Company's collector is a scaled-up version of their LEC-460 system, a dual-axis-tracking solar concentrator with the optical element balanced with the receiver on a cantilevered, equatorial mount. The 95 facets are made of polyethylene film stretched over aluminum rims 54 in. in diameter. A vacuum is applied to the region between the front and back surface films to focus the facet.

Status/Accomplishments:

When the collector was assembled at the test facility, a number of problems with the drives and the stiffness of the structure were discovered. Therefore, the collector was dismantled; the bearings were redesigned and repaired; and the concentrator was reassembled. Sandia completed testing of the collector during FY 1989.

Testing showed that 128 kW_t were collected at a collector efficiency of about 85%. The peak flux measured was about 2800 suns.

FY 1990 Milestones:

None--Project completed.

Major Project Reports:

Phase I Design Reports were completed in March 1986. The Test Report is in preparation and is scheduled for January 1990.

Summary Date: October 1989

Contract Electrician

Project/Area/Task:
Distributed Receiver Technology

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. M. Stomp, Jr.

Telephone: (505) 844-1579

Contractor:
J & S Electric Co., Inc.
501 Eubank, SE, Suite 201
Albuquerque, NM 87123

Principal Investigator: J. Salas

Telephone: (505) 293-0160

Contract Number: SNL 23-2639

Contract Period: 10/88 – 03/89 (Closed 3/08/89)

Contract Funding (Source):
FY 1989: $15,000 (DOE)

Objective:

To provide journeyman electrician with high-voltage and low-voltage controls experience to assist with the installation, start-up, modification, and maintenance of all electrical subsystems at the Solar Thermal Test Facility (STTF).

Approach/Background:

Provide one journeyman electrician to meet objective.

Status/Accomplishments:

One journeyman electrician was provided to aid in the design layout for the direct absorption receiver (DAR) salt receiver panel structure and heat dump, the modification and installation of the Engine Test Facility (ETF) test cell services, the modification and maintenance of the parabolic trough system used for the toxic waste tests, and the modification and maintenance of the Small Community Test Site services.

FY 1990 Milestones:

Completion of DAR H2O test loop; completion of basic test cell services at the ETF.

Major Project Reports: None

Summary Date: October 1989

Contract Electrician

Project/Area/Task:
Distributed Receiver Technology

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. M. Stomp, Jr.

Telephone: (505) 844-1579

Contractor:
J & S Electric Co., Inc.
501 Eubank, SE, Suite 201
Albuquerque, NM 87123

Principal Investigator: J. Salas

Telephone: (505) 293-0160

Contract Number: SNL 75-7415

Contract Period: 03/89 – 03/92

Contract Funding (Source):
FY 1989: $35,000 (DOE)

Objective:

To provide journeyman electrician with high-voltage and low-voltage controls experience to assist with the layout, installation, start-up, modification, and maintenance of all electrical subsystems at the Solar Thermal Test Facility (STTF).

Approach/Background:

Provide one journeyman electrician to meet objective.

Status/Accomplishments:

One journeyman electrician was provided to aid in the design and layout for the direct absorption receiver salt receiver, the modification and installation of the Engine Test Facility (ETF) test cell services, the modification and maintenance of the parabolic trough test site, the installation of modifications and update of Small Community Test Site services, and the layout and design of services for the new solar furnace.

FY 1990 Milestones:

Completion of modifications to the test cell services at the ETF; completion of modifications to the Small Community Test Site.

Major Project Reports: None

Summary Date: October 1989

Technician Support

Project/Area/Task:
Conversion Devices/Receiver Development

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: R. B. Diver

Telephone: (505) 846-0215

Contractor:
Kirk Mayer, Inc.
114 Washington, SE
Albuquerque, NM 87105

Principal Investigator: W. C. Ginn

Telephone: (505) 844-7473

Contract Number: SNL 01-9646

Contract Period: 12/86 – 12/89

Contract Funding (Source):
FY 1987: $60,000 (DOE)
FY 1988: $25,000 (Sandia IR&D)
FY 1989: $25,000 (DOE)

Objective:

To provide technician support to assist in the development of distributed receiver technology and hardware.

Approach/Background:

Design and fabricate reflux heat-pipe solar receivers.

Status/Accomplishments

Fabricated the Sandia 75-kW reflux heat-pipe receiver and assisted in testing. Also supported the fabrication of the Sandia bench-test facility.

Major Project Reports: None

Summary Date: October 1989

Free-Piston Stirling Engine Technology

Project/Area/Task:
Conversion Devices

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: K. L. Linker

Telephone: (505) 846-7817

Contractor:
NASA Lewis Research Center (NASA/LeRC)
21000 Brookpark Rd.
Cleveland, OH 44135

Principal Investigator: R. K. Shaltens

Telephone: (216) 433-6138

Contract Number: DE-AM04-80AL13137
(Task Order Number DE-AT04-85AL33408)

Contract Period: 10/85 – 12/92

Contract Funding (Source):
FY 1986: $475,000 (DOE)
FY 1987: $300,000 (DOE)
FY 1988: $300,000 (DOE)
FY 1989: $1,209,000 (DOE)

Objective:

To develop a free-piston Stirling engine (FPSE) for dish-electric systems that has the potential of meeting DOE's long-term performance and cost goals.

Approach/Background:

Under a DOE/Albuquerque Operations Office Interagency Agreement (IAA), NASA LeRC is providing technical management of this effort to develop an FPSE that has the potential for low maintenance and long life (over 60,000 hours). In Phase I, two industrial contractors, Mechanical Technology, Inc. (MTI), and Stirling Technology Company (STC) developed conceptual designs. The MTI design uses a system of gas springs to provide a coupling of the displacer and power pistons to drive a linear alternator. The design also calls for a wicked sodium heat-pipe reflux boiler. The STC design features a potassium pool boiler receiver. In Phase II, a preliminary design will be developed based on the designs in Phase I.

Status/Accomplishments:

A modification to the DOE/NASA IAA was completed in February 1989, extending the agreement through December 1992. A request for proposal for the follow-on effort was released when the extension was approved. Phase II will consist of a preliminary design of a 25-kW_e FPSE based on the Phase I conceptual designs. Proposals were received from the following contractor teams: Cummins Engine Company (CEC) of Columbus, Ind.; MTI of Latham, N.Y.; and STC of Richland, Wash.

NASA/LeRC and Sandia completed technical review of the proposals in August 1988 and recommendation was made to the Lewis Source Selection Official. Selection of CEC and STC was made during the first quarter of FY 1989. Both CEC and STC have been working on their preliminary designs.

Major Project Reports:

Mechanical Technology Incorporated, *Conceptual Design of an Advanced Stirling Conversion System for Terrestrial Power Generation.*

Stirling Technology Company, *25 kW_e Solar Thermal Stirling Hydraulic Engine System, Final Conceptual Design Report.*

Summary Date: October 1989

Optical Materials/Inorganic Mirrors

Project/Area/Task:
Optical Materials and Procedures

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: T. R. Mancini

Telephone: (505) 844-8643

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: T. R. Mancini

Telephone: (505) 844-8643

Contract Number: DE-AC04-76-DP00789

Contract Period: 10/88 – 09/89

Contract Funding (Source):
FY 1987: $159,000 (DOE)
FY 1988: $208,000 (DOE)
FY 1989: $175,000 (DOE)

Objective:

To develop an organically protected silvered surface directly on a thin metal substrate for use in stretched-membrane heliostats and dishes.

Approach/Background:

The development of optical materials at Sandia is pursued in those areas where Sandia has a unique expertise and a well-defined component application exists.

The development of metal mirrors is one of these areas. If silvered metal foils can be used for stretched-membrane solar collectors, heliostats, and dishes, the resulting structures will be highly efficient because the optical surface is a load-bearing part of the structure. If the structure is more efficient, it will also be more cost effective.

Status/Accomplishments:

Mirrors produced to date utilize sol-gels as the planarizing dielectric layer over the metal surface. Sol-gel glasses are produced using metal alkoxides as the glass precursors. In catalyzed alcoholic solutions, the metal alkoxides partially hydrolize to form glasslike polymer networks. Mirrors produced have demonstrated excellent reflectivity of 0.94 within a 15-mrad cone angle and having one standard deviation of about 1 mrad, comparable to good glass mirrors.

The emphasis during FY 1989 was on defining a suitable, inorganic protective overcoat for the silver surface. Two potential protective overcoats were identified, and the results of environmental testing are very encouraging.

FY 1990 Milestones:

June 1990--Conduct cost study for the production of stainless steel mirrors.

Major Project Reports: None

Summary Date: October 1989

Central Receiver Solar Thermal Study

Project/Area/Task:
Central Receiver Technology

Directing Organization:
Albuquerque Operations Office
U.S. Department of Energy
P.O. Box 5400
Albuquerque, NM 87115

Project Manager: N. D. Lackey

Telephone: (505) 846-3220

Contractor:
Pacific Gas and Electric Company
3400 Crow Canyon Road
San Ramon, CA 94583

Principal Investigator: G. W. Braun

Telephone: (415) 866-5559

Contract Number: DE-FC04-86AL38740

Contract Period: 06/86 – 09/89

Contract Funding (Source):
FY 1986: $1,000,000 (DOE)
FY 1987: $485,260 (DOE)
FY 1988: $200,000 (DOE)
FY 1989: $200,000 (DOE)

Objective:

To study the appropriate path to eventual commercialization of solar central receiver technology. The purpose of these utility studies is to have the users of the solar central receiver systems evaluate the state-of-the-art technology, select subsystem and integrated system design, and provide conceptual design, and define an experimental program to verify the adequacy of the designs.

Approach/Background:

The Phase I conceptual design study was completed in FY 1987. Phase II is to define the path to commercialize central receiver technology, including a definition of research and development needs to reduce the technical and financial risks. Phase IIC was completed in FY 1989.

Status/Accomplishments:

During FY 1989, Phase IIC studies were completed; the Final Review Meeting was held August 11, 1989.

Major Project Reports:

The Phase IIC Report was received.

Summary Date: October 1989

Parabolic Dishes/Dish Support Project

Project/Area/Task:
Parabolic Dishes

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: T. R. Mancini

Telephone: (505) 844-8643

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: T. R. Mancini

Telephone: (505) 844-8643

Contract Number: DE-AC04-76-DP00789

Contract Period: 10/88 – 09/89

Contract Funding (Source):
FY 1987: $450,000 (DOE)
FY 1988: $457,000 (DOE)
FY 1989: $500,000 (DOE)

Objective:

To provide contract monitoring, testing, and technical support for dish collector development projects.

Approach/Background:

Technical and fiscal contract monitoring for Sandia subcontracts is provided under this contract. Technical support for all dish development projects is also provided.

Status/Accomplishments:

Technical support has been provided for the analysis and redesign of the LaJet Innovative Concentrator. In addition, technical support was provided for the SKI Stretched-Membrane Dish Development Project.

FY 1990 Milestones:

November 1989--Place contracts for faceted stretched-membrane dish development.

February 1990--7-m-diameter stretched-membrane optical element delivered to Sandia for testing.

March 1990--Make decision on the development of a faceted stretched-membrane dish concentrator.

Major Project Reports: None

Summary Date: October 1989

Low-Cost Drive Mechanism for Heliostats

Project/Area/Task:
Heliostats

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. W. Grossman

Telephone: (505) 846-5482

Contractor:
Peerless-Winsmith, Inc.
172 Eaton St.
Springville, NY 14141

Principal Investigator: W. H. Heller

Telephone: (716) 592-9311

Contract Number: SNL 90-5753

Contract Period: 06/86 – 11/88

Contract Funding (Source):
FY 1987: $347,036 (DOE)
FY 1988: $140,304 (DOE)
FY 1989: -0- (---)

Objective:

In 1986, cost estimates for heliostat drives were approximately $\$32/m^2$ of heliostat area. This program was initiated to develop a drive mechanism for heliostats that can be produced in quantities of 50,000/year at a cost between $11 and $\$14/m^2$ of heliostat area.

Approach/Background:

An innovative design approach was employed using an open-ball screw for the elevation drive and an orbiting-plate gear for the azimuth drive. The drive mechanism was sized to support a 150-m^2 heliostat. Three prototypes were to be built for testing at the Solar Thermal Test Facility.

Status/Accomplishments:

Evaluation of the first unit tested to destruction revealed severe brinelling on the drive eccentrics because of inadequate hardening. Peerless-Winsmith provided replacement eccentrics for all three drive units. The azimuth drive housing on the unit installed on the Advanced Thermal Systems (ATS) heliostat failed when water that had leaked into the housing froze. The housings for all three units were modified to prevent water ingress. The third unit originally slated for environmental tests in FY 1989 was placed in service on the ATS heliostat after the modifications were completed. The second unit will be loaned to the Electric Power Research Institute for evaluation as a photovoltaic concentrator tracker.

Major Project Reports:

Peerless-Winsmith, Inc., *Development of a Low-Cost Drive Tracking Mechanism for Solar-Heliostats or PV Arrays.*

Summary Date: October 1989

Chemical Analyses and Analyses System Conceptual Design

Project/Area/Task:
High-Temperature Solar Destruction of Hazardous Wastes

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. L. Sprung

Telephone: (505) 844-0134

Contractor:
Delphi Research, Inc.
701 Haines Ave., NW
Albuquerque, NM 87102

Principal Investigator: P. M. Dhooge

Telephone: (505) 243-3111

Contract Number: SNL 75-6779

Contract Period: 10/88 – 09/89

Contract Funding (Source):
FY 1989: $50,000 (SNLA)

Objectives:

To perform wet chemical analysis of quench water and the contents of condensate traps for SOLTOX experiments and to develop a conceptual design for an effluent analysis train for the SOLTOX facility that meets Environmental Protection Agency (EPA) monitoring and permitting requirements.

Approach/Background:

Determination of the chemical conversions produced during catalytic reforming experiments conducted in Sandia's direct catalytic absorption receiver (DCAR) requires determination of organics, free halogen (e.g., Cl-), and pH in quench water and of trace organics in condensate traps. During FY 1989, these analyses were performed under contract by Delphi Research, Inc. As a part of this contract, Delphi Research also developed a conceptual design for an effluent analysis train for the SOLTOX facility that would meet all EPA monitoring and permitting requirements.

Status/Accomplishments:

For each SOLTOX experiment performed during FY 1989, Delphi determined the pH (titration), Cl-content (iodometric method), dissolved H_2, CO, CO_2, and organics (gas chromatography) in the quench water of the DCAR in which the SOLTOX experiments were conducted. Trace organics in condensate traps were also identified by gas chromatographic analysis.

Delphi also developed a conceptual design for an analysis train for the SOLTOX facility that meets all EPA monitoring and permitting requirements. The recommended design would analyze for halogens, acidic gases, and organics using a photoionization detector gas chromatograph that feeds a mass spectrometer. Gases not condensed in the effluent train (principally, H_2, CO, and CO_2) would continue to be analyzed using the current analysis train (infrared analyzer, thermal conductivity gas chromatograph). The recommended analytic methods should allow trace organics to be detected at the 50-ppb level.

Major Project Reports:

Dhooge, P. M., *An Effluent Analysis System Design for Sandia National Laboratories SOLTOX Facility.*

Summary Date: October 1989

High-Temperature Solar Destruction of Toxic Chemicals

Project/Area/Task:
High-Temperature Solar Destruction of Hazardous Waste

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. L. Sprung

Telephone: (505) 844-0134

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigators: J. M. Fish, J. L. Sprung

Telephone: (505) 844-0134

Contract Number: DE-AC04-76-DP00789

Contract Period: 10/88 – 09/89

Contract Funding (Source):
FY 1989: $850,000 (DOE)

Objectives:

To demonstrate that solar thermal catalytic reforming is an efficient way to destroy toxic organic chemicals and to design and demonstrate a prototype solar reforming system.

Approach/Background:

Catalytic reforming is widely used in the petroleum industry to increase gasoline octane ratings. When organics are catalytically reformed in the presence of an oxygen source (CO_2, H_2O), the organic is converted to CO, CO_2, and H_2. Halogens in halocarbons are converted to halogen acids (e.g., HCl). Reforming is normally a high-temperature process. By-product formation during reforming (e.g., coking) can be minimized by running with excess steam and using a radiant energy heat source that suppresses gas-phase thermal reactions.

Status/Accomplishments:

At the University of Houston, (1) bench tests demonstrated that methane and tricloroethane can be efficiently destroyed by reforming over Rh metal using natural gas as a radiant energy source, (2) screening studies of base (Ni, Fe) and noble (Pt, Ru, Rh) metal catalyzed carbon dioxide reforming of methane indicated that best results (superior catalyst lifetimes, adequate conversion) were obtained using 0.5% Rh coated on Al_2O_3 pellets, and (3) a thermochemical model for CO_2 reforming of methane over Rh was developed.

At Sandia, several organic dyes, methane, 1-propanol, and trichloroethylene were destroyed by steam reforming over Rh coated on porous Al_2O_3 ceramic supports using solar energy from the Central Receiver Test Facility solar furnace as the heat source. Two test reactors were constructed, one of glass that did not survive the thermal stresses induced by the intense solar flux and one of aluminum (with internal Alumina insulation) that did survive the thermal stresses. The methane experiments confirmed that CO_2 or H_2O reforming produces equilibrium conversion of methane to products. A model of the high-temperature, catalytic reforming of CH_4 in a solar-driven reactor, which could easily be extended to other organic substrates, was developed. Post-test wet chemical analyses of quench water from the 1-propanol and trichloroethylene experiments showed that the substrate destruction had been complete (ppm levels of substrate in the quench water).

Major Project Reports:

Keehan, K., and J. T. Richardson, *Carbon Monoxide Rich Methanation Kinetics on Supported Rhodium and Nickel Catalysts.*

Hogan, R. E., and R. D. Skocypec, *Analysis of Catalytically Enhanced Solar Absorption Chemical Reactors: I - Basic Concepts and Numerical Model Description, II - Predicted Characteristics of a 100 kW Reactor.*

Summary Date: October 1989

Reflux Heat-Pipe Solar Receivers

Project/Area/Task:
Distributed Receiver Technology/Receivers

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: R. B. Diver

Telephone: (505) 846-0215

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: R. B. Diver

Telephone: (505) 846-0215

Contract Number: DE-AC04-76-DP00789

Contract Period: Ongoing

Contract Funding (Source):
FY 1987: $300,000 (DOE)
FY 1988: $600,000 (DOE)
FY 1989: $700,000 (DOE)

Objective:

To develop the reflux heat-pipe solar receiver for dish-electric Stirling systems through analytic design and experimental activities.

Approach/Background:

Stirling dish-electric systems have been identified as having potential for meeting DOE long-term energy cost goals. Dish-electric systems based on Stirling engine technology were successfully demonstrated by Advanco Corp. and McDonnell Douglas Corp. and showed the potential for high efficiency. To reach the ultimate potential for dish-electric systems, a high-efficiency, low-maintenance, low-cost receiver is required. The current development thrust is to improve the longevity and reduce the operations and maintenance costs of these systems as well as to improve performance and raise operating temperatures.

The reflux heat-pipe receiver represents the next step in the evaluation of Stirling receiver technology and has the potential to address all the shortcomings of the previous designs. In the reflux heat-pipe solar receiver, a liquid metal such as sodium or potassium is used as an intermediate heat-transfer fluid between a solar receiver/absorber and the heater tubes of a Stirling engine. The liquid metal is evaporated from the back side of the solar absorber and flows to the Stirling engine's heater tubes, where it condenses. The liquid metal is then passively returned to the evaporator by gravity, capillary forces in a wick, or a combination of the two effects.

Status/Accomplishments:

In FY 1989, a facility for bench testing small-scale proof-of-concept hardware was used to evaluate and develop reflux boiler and screen-wick heat-pipe designs. On-sun test of full-scale prototype hardware also confirmed the reflux receiver's potential for high efficiency. A significant amount of technical information was provided to industry to support commercially funded developments based on this technology. Computer programs for the design and analysis of reflux heat-pipe receivers were expanded and used in the analysis of results.

Major Project Reports:

Adkins, D. R., *Analysis of Heat Pipe Receivers for Point-Focus Solar Concentrators.*

Andraka, C. E., and R. B. Diver, *Reflux Heat-Pipe Solar Receivers for Dish-Electric Systems.*

Andraka, C. E., and J. B. Moreno, *Pool Boiler Reflux Solar Receiver for Stirling Dish-Electric Systems.*

Diver, R. B., J. D. Fish, R. Levitan, M. Levy, E. Meirovitch, H. Rosin, S. A. Paripatyadar, and J. T. Richardson, *Solar Test of an Integrated Sodium Reflux Heat-Pipe Receiver/ Reactor for Thermochemical Energy Transport.*

Moreno, J. B., and C. E. Andraka, *Test Results from Bench-Scale Sodium-Pool-Boiler Solar Receiver.*

Summary Date: October 1989

Optimization of a Commercial-Scale Stretched-Membrane Heliostat

Project/Area/Task:
Heliostats

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185-5800

Project Manager: D. J. Alpert

Telephone: (505) 844-6982

Contractor:
Science Applications International Corporation
10401 Roselle St.
San Diego, CA 92121

Principal Investigator: K. Beninga

Telephone: (619) 458-3760

Contract Number: SNL 05-7867

Contract Period: 11/88 – 09/89

Contract Funding (Source):
FY 1989: $168,960 (DOE)

Objective:

To integrate the existing design for a stretched-membrane mirror module into a fully integrated, market-ready heliostat.

Approach/Background:

A 150-m^2, commercial-scale stretched-membrane heliostat was previously designed and documented. In developing the design, the heliostat's drive and support structure were specifically excluded from consideration; rather, a single, rear-mounted pedestal--as used on glass-mirror heliostats--was assumed. However, a single-pedestal support does not take full advantage of the unique structural characteristics of stretched-membrane reflectors; a more cost-efficient design might be possible. Moreover, a pedestal support does not allow stowing the mirror module in a face-down orientation. The useful life of the reflective film could be extended and the frequency of cleaning reduced if the heliostat were stowed face down. The contract is divided into two phases. The objective of the first phase is to determine if a cost-effective alternative to a single-pedestal heliostat mount exists; in phase two, a detailed design and cost comparison for the market-ready heliostat will be performed.

Status/Accomplishments:

Alternative approaches for driving and supporting a stretched-membrane heliostat were evaluated. A design using two 50-m^2 mirror modules on a single pedestal was selected as the best for near-term commercial markets. A detailed design and cost comparison of the preferred design was completed. A draft report of all aspects of the contract was completed.

Major Project Reports: None

Summary Date: October 1989

Stretched-Membrane Heliostat Development

Project/Area/Task:
Heliostats

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: D. J. Alpert

Telephone: (505) 844-6982

Contractor:
Science Applications International Corporation
10401 Roselle St.
San Diego, CA 92121

Principal Investigator: K. Beninga

Telephone: (619) 458-3760

Contract Number: SNL 33-1226

Contract Period: 04/87 – 08/89

Contract Funding (Source):
FY 1987: $423,463 (DOE)
FY 1988: $74,437 (DOE)
FY 1989: $5,267 (DOE)

Objective:

To develop an improved design for a stretched-membrane heliostat for use in solar central receiver electric power or process heat applications.

Approach/Background:

The design and fabrication of the first prototype mirror module identified a number of areas where design improvements or additional cost savings might be possible. Building on previous work, the contractor will develop an improved commercial-scale heliostat design. In addition, the contractor will design and build a 50-m^2 prototype stretched-membrane mirror module that is as representative as possible of the commercial design. The prototype mirror module will be installed at the Central Receiver Test Facility for testing by Sandia.

Status/Accomplishments:

The design of an improved commercial-scale heliostat was completed. A prototype mirror module was built and installed at the Solar Thermal Test Facility. A report documenting all aspects of the contract was completed. All tasks of the contract were completed.

Major Project Reports:

Science Applications International Corp., *An Improved Design for a Stretched-Membrane Heliostat.*

Summary Date: October 1989

Solar Detoxification of Water Project

Project/Area/Task:
Solar Processing of Dilute Aqueous Chemical Wastes

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: C. E. Tyner

Telephone: (505) 846-3340

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: J. E. Pacheco

Telephone: (505) 846-9698

Contract Number: DE-AC04-76-DP00789

Contract Period: 10/88 – 09/89

Contract Funding (Source):
FY 1988: -0- (---)
FY 1989: $85,000 (HAZWRAP)
$700,000 (DOE)

Objective:

To develop and demonstrate an effective photocatalytic process using solar energy to destroy dilute organic contaminants in water.

Approach/Background:

Extensive literature on photocatalysis has shown that near ultraviolet (UV) illuminated titanium dioxide can completely destroy most organic contaminants in water. Engineering-scale tests are being conducted at the Solar Thermal Test Facility to demonstrate the effectiveness of the photocatalytic process to treat contaminated water. The effects of process variables on the destruction efficiency, reaction completeness, and throughput using a large (465-m^2) parabolic trough system are being investigated. These experiments are addressing full-scale systems issues aimed at a demonstration of the technology in 1991.

Status/Accomplishments:

Proof-of-concept tests with a model organic chemical, salicylic acid, were conducted in addition to tests with an actual pollutant, trichloroethylene. Tests have shown destruction of these compounds can occur to below detectable levels in a single pass. The catalyst loading and oxidant (hydrogen peroxide) concentration effects on the destruction rates were quantified for the model compound. The effect of UV intensity was also determined. The results can be summarized as follows:

- The optimal catalyst loading is approximately 0.1% by weight.
- Hydrogen peroxide along with the catalyst substantially increased reaction rates over either agent acting alone. These results have a significant, positive effect on the economics of the process.
- Reaction rates were found to be linearly proportional to UV intensity.

Major Project Reports:

Holmes, J. T., and C. A. Haslund, A Solar *Photochemical Process for Destroying Organics in Water.*

Tyner, C. E., et al., *Rapid Destruction of Organic Chemicals in Groundwater Using Sunlight.*

Pacheco, J. E., and J. T. Holmes, *Falling-Film and Glass-Tube Solar Photocatalytic Reactors for Treating Contaminated Water.*

Summary Date: October 1989

Stretched-Membrane Heliostat Development

Project/Area/Task:
Heliostats

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: D. J. Alpert

Telephone: (505) 846-1976

Contractor:
Solar Kinetics, Inc.
10635 King William Dr.
Dallas, TX 75220

Principal Investigator: J. A. Hutchison

Telephone: (214) 556-2376

Contract Number: SNL 33-1227

Contract Period: 03/87 – 06/89

Contract Funding (Source):
FY 1987: $449,800 (DOE)
FY 1988: $112,200 (DOE)
FY 1989: $142,495 (DOE)

Objectives:

To develop an improved design for a stretched-membrane heliostat for use in solar central receiver electric power or process heat applications.

Approach/Background:

The design and fabrication of the first prototype mirror module identified a number of areas where design improvements or additional cost savings might be possible. Building on the previous work, the contractor will develop an improved commercial-scale heliostat design. In addition, the contractor will design and build a 50-m^2 prototype stretched-membrane mirror module that is as representative as possible of the commercial design. The prototype mirror module will be installed at the Central Receiver Test Facility for testing by Sandia.

Status/Accomplishments:

The design of an improved commercial-scale heliostat was completed. A prototype mirror module was built and installed at the Solar Thermal Test Facility. A draft report documenting all aspects of the contract was completed.

Major Project Reports:

Design and Demonstration of an Improved Stretched-Membrane Heliostat, 1989, Solar Kinetics, Inc., SAND89-7028, Albuquerque, NM: Sandia National Laboratories.

Summary Date: October 1989

Stretched-Membrane Dish Development Project, Phase II

Project/Area/Task:
Parabolic Dishes

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: T. R. Mancini

Telephone: (505) 844-8643

Contractor:
Solar Kinetics, Inc. (SKI)
P.O. Box 540636
Dallas, TX 75354-0636

Principal Investigators: J. A. Hutchison, D. L. White

Telephone: (214) 556-2376

Contract Number: SNL 55-2495

Contract Period: 04/88 – 08/90

Contract Funding (Source):
FY 1988: $900,000 (DOE)
FY 1989: $500,000 (DOE)

Objective:

To develop a 12-m-diameter stretched-membrane dish collector.

Approach/Background:

The SKI stretched-membrane dish design makes use of a free-form yielded metal membrane with an optical membrane of ECP 300 silvered film over the top. In Phase I of the project, SKI demonstrated the fabrication technique. Under this contract, SKI will resolve issues associated with the membrane materials, fabrication techniques, and the optical effect of the seams. Once the membrane fabrication issues are resolved, SKI will build a 7-m-diameter optical element to be installed on an existing pedestal. Following the successful demonstration of the 7-m optical element, they will design and build a stretched-membrane solar collector about 12 m in diameter and compatible with a 25-kW Stirling engine.

Status/Accomplishments:

The contractor completed the evaluation of Task 1: membrane fabrication issues, the metal and polymer seams, repeatability of fabricating the plastically deformed metal membranes, and the development of a design for the 7-m-diameter optical element.

FY 1990 Milestones:

February 1990--Deliver 7-m optical element to Sandia Solar Thermal Test Facility for evaluation.

Major Project Reports:

Solar Kinetics, Inc., *Development of a Stretched-Membrane Dish Task 1, Phase II Topical Report.*

Summary Date: October 1989

Screen-Wick Heat-Pipe Technology

Project/Area/Task:
Distributed Receiver Technology

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: R. B. Diver

Telephone: (505) 846-0215

Contractor:
Stirling Thermal Motors, Inc. (STM)
2841 Boardwalk
Ann Arbor, MI 48104

Principal Investigator: T. Godett

Telephone: (313) 995-1755

Contract Number: SNL 33-3036

Contract Period: 04/87 – 02/90

Contract Funding (Source):
FY 1987: $124,000 (DOE)
FY 1988: $31,000 (DOE)
FY 1989: $172,000 (DOE)

Objectives:

To design and fabricate four gas-fired heat pipes to operate with the STM4-120 kinematic Stirling engine delivered to Sandia under contract 53-8452 and to develop and fabricate two solar flux receivers based on heat-pipe technology.

Approach/Background:

To test the STM4-120 kinematic Stirling engine "on sun," a solar heat-pipe reflux receiver is required. The solar receiver efficiently absorbs the sun's concentrated energy and transports the heat to the engine via heat pipes. STM has considerable experience in the field of heat-pipe technology and is intimately and uniquely familiar with the interface requirements of their own STM4-120 engine. To test the STM4-120 delivered to Sandia, four gas-fired heat pipes will be required. These heat pipes will allow the STM4-120 to be demonstrated in a test cell without solar energy.

Status/Accomplishments:

STM delivered to Sandia the four gas-fired heat pipes, and Sandia tuned the gas combustion system connected to these units. In FY 1989, STM and Sandia did considerable analysis of the fabrication techniques for screen-wick heat-pipe receivers. Sandia approved the design, and STM is continuing with procurement and fabrication.

Major Project Reports:

Khalili, K., T. Godett, and R. J. Meijer, *Design and Testing of a Heat Pipe Gas Combustion System for the STM4-120 Stirling Engine.* Sandia National Laboratories. Also in *Proceedings of the 24th Intersociety Energy Conversion Engineering Conference*, Paper No. 899540, Washington, DC, August 6-11, 1989.

Summary Date: October 1989

Kinematic Stirling Engine Technology

Project/Area/Task:
Conversion Devices

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: K. L. Linker

Telephone: (505) 846-7817

Contractor:
Stirling Thermal Motors, Inc. (STM)
2841 Boardwalk
Ann Arbor, MI 48104

Principal Investigator: T. Godett

Telephone: (313) 995-1755

Contract Number: SNL 53-8452

Contract Period: 07/86 – 12/89

Contract Funding (Source):
FY 1986: $299,950 (DOE)
FY 1988: $5,000 (DOE)
FY 1989: $15,000 (DOE)

Objective:

To demonstrate the STM kinematic Stirling engine for a dish-electric system that has near-term commercialization potential and meets DOE's performance and cost goals.

Approach/Background:

The kinematic Stirling cycle engine has been considered for several years as a near-term heat engine for the Solar Thermal Electric Technology dish-electric applications. In an effort to advance the Stirling technology toward longer life and commercialization, Sandia recently acquired an STM 25-kW kinematic Stirling engine, STM4-120, for evaluation. This engine was designed from the outset to be a long-life, commercial product engine.

Status/Accomplishments:

In FY 1988, STM demonstrated the engine at its facility and produced 23 kW of shaft power at a conversion efficiency of 40%. This measured power and efficiency agreed with the computer-modeling predictions for this engine. After operating approximately 50 hours, STM delivered the engine to Sandia in September 1988 for further testing. Sandia has operated the STM4-120 at its engine test facility. The engine has operated for more than 20 hours and produced 7.4 kW of shaft power at a reduced pressure in the helium working fluid. Full-pressure tests are scheduled to begin in early FY 1990. In late FY 1990, a reflux heat-pipe or pool boiler receiver will be combined with this engine and tested on one of Sandia's test-bed concentrator dishes.

Major Project Reports: None

Summary Date: October 1989

Kinematic Stirling Engine Technology

Project/Area/Task:
Conversion Devices

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: K. L. Linker

Telephone: (505) 846-7817

Contractor:
Stirling Thermal Motors, Inc. (STM)
2841 Boardwalk
Ann Arbor, MI 48104

Principal Investigator: T. Godett

Telephone: (313) 995-1755

Contract Number: SNL 75-8851

Contract Period: 04/89 - 12/90

Contract Funding (Source):
FY 1989: $365,550 (DOE)

Objective:

To demonstrate the STM kinematic Stirling engine with a reflux sodium receiver on sun.

Approach/Background:

Under Sandia contract 53-8452, STM has delivered an STM4-120 to Sandia for performance testing. The engine will use gas combustion for the heat source. Determining the performance and reliability of an engine on sun will be the goal of the engine obtained under this contract, 75-8851. The second engine will be incorporated with a solar receiver and will contain several minor changes to improve the performance and reliability.

Status/Accomplishments:

The contract was placed for the engine. STM began the assembly and cold motoring of its engine. Delivery to Sandia is scheduled for the second quarter of FY 1990.

Major Project Reports: None

Summary Date: October 1989

Technical Support Services

Project/Area/Task:
Distributed Receiver Technology

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: R. B. Diver

Telephone: (505) 846-0215

Contractor:
Tech Reps, Inc.
5000 Marble Ave., NE
Albuquerque, NM 87114

Principal Investigator: W. Jones

Telephone: (505) 262-2077

Contract Number: SNL 01-2370

Contract Period: 12/86 – 12/89

Contract Funding (Source):
FY 1987: $50,000 (DOE)
FY 1988: $50,000 (DOE)
FY 1989: -0- (---)

Objective:

To provide technical support services to Sandia to help in the reporting and transfer of distributed receiver technology.

Approach/Background:

To provide support services for technical illustrations and preparation of technical and quarterly reports.

Status/Accomplishments:

Provided continuing technical support.

Major Project Reports: None

Summary Date: October 1989

Solar Collector Pedestal Fabrication, Assembly, and Installation

Project/Area/Task:
Parabolic Dishes/Acurex Pedestal

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: T. R. Mancini

Telephone: (505) 844-8643

Contractor:
TIW Fabrication and Machining Inc.
1255 Coors Road, SW
P.O. Box 12156
Albuquerque, NM 87195

Principal Investigator: T. McLellan

Telephone: (505) 242-5251

Contract Number: SNL 57-4436

Contract Period: 09/87 – 12/89

Contract Funding (Source):
FY 1987: $57,140 (DOE)
FY 1988: -0- (---)
FY 1989: -0- (---)

Major Project Reports: None

Summary Date: October 1989

Objectives:

To fabricate a solar collector pedestal per drawings provided by Sandia. To assemble the drive and install it at Sandia's Solar Thermal Test Facility.

Approach/Background:

The redesigned Acurex Innovative Concentrator pedestal is being built to accommodate the 7-m stretched-membrane optical element to be fabricated by Solar Kinetics during Phase II of its contract. This all-purpose pedestal will serve as a test bed for solar concentrator optical elements and will eliminate the need to build a new pedestal for each design.

Status/Accomplishments:

The fabrication of the pedestal was completed in FY 1988 and delivered to Sandia in early FY 1989. The project is complete.

Catalyst Development and Reactor Modeling

Project/Area/Task:
High-Temperature Solar Destruction of Hazardous Wastes

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. L. Sprung

Telephone: (505) 844-0134

Contractor:
University of Houston
4800 Calhoun St.
Houston, TX 77004

Principal Investigator: J. T. Richardson

Telephone: (713) 749-2419

Contract Number: SNL 55-4032

Contract Period: 10/88 – 09/89

Contract Funding (Source):
FY 1989: $75,000 (DOE)

Objective:

To investigate catalysts and measure fundamental reaction rate constants in support of Sandia's SOLTOX program.

Approach/Background:

In support of the SOLTOX program, in January 1988, SNL contracted with Professor J. Richardson of the University of Houston, an expert in catalysis and reforming chemistry, to identify reforming catalysts appropriate for use in the SOLTOX direct catalytic absorption receiver pilot-scale reactor, to determine rates of steam reforming of representative organic compounds (e.g., trichloroethylene [TCE] and methane) over promising catalysts, and to investigate degradation of these catalysts during reforming. Because these experiments are performed in a bench-scale reactor, they yield quantitative kinetic data catalyst performance and the destruction rate of the organic substrate.

Status/Accomplishments:

The rates of methane reforming over Rh metal deposited on porous ceramic supports were measured at temperatures as high as 1000°C. The measured rates were 5 to 10 times greater than those obtained previously for reforming of methane over Rh metal deposited on pellets. The rate of steam reforming of TCE over Rh metal was measured. The measurements indicated that 99.9999% destruction of TCE can be achieved at 800°C, which substantially exceeds the Resource Conservation and Recovery Act requirement of 99.99% destruction.

Major Project Reports:

Keehan, K., and J. T. Richardson, *Carbon Monoxide Rich Methanation Kinetics on Supported Rhodium and Nickel Catalysts.*

Summary Date: October 1989

Point-Focus Concentrator Structural Analysis

Project/Area/Task:
Structural Analysis

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: C. P. Cameron

Telephone: (505) 844-8363

Contractor:
W G Associates
6607 Stonebrook Circle
Dallas, TX 75420

Principal Investigator: V. Goldberg

Telephone: (214) 233-4729

Contract Number: SNL 33-1510

Contract Period: 01/87 – 08/89

Contract Funding (Source):
FY 1987: $99,500 (DOE)
FY 1988: $20,000 (DOE)
FY 1989: $25,000 (DOE)

Objectives:

To assist Sandia in reviewing structural analysis of solar concentrators that are or will be constructed at Sandia's National Solar Thermal Test Facility. To support Sandia in conducting structural modifications or repairs to existing concentrators.

Approach/Background:

Review the adequacy of concentrator structural designs with an emphasis on possibility of structural failure and on structural deflections that affect performance.

Status/Accomplishments:

Reviewed designs for stretched-membrane concentrator program. Designed attenuator for a large solar furnace.

Major Project Reports: None

Summary Date: October 1989

Volumetric Receivers (VR) Design and Testing

Project/Area/Task:
Central Receiver Technology

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. M. Chavez

Telephone: (505) 844-4485

Contractor:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: J. M. Chavez

Telephone: (505) 844-4485

Contract Number: DE-AC04-76-DP00789

Contract Period: 05/87 – 10/89

Contract Funding (Source):
FY 1987: $20,000 (DOE)
FY 1988: $50,000 (DOE)
FY 1989: $75,000 (DOE)

Objectives:

To participate in testing and in keeping up to date on VR development. In a VR, air is drawn through a porous absorber (heat exchanger) on which the solar energy is concentrated and absorbed. The volumetric air receiver concept was proposed as an advanced receiver that would allow the use of higher fluid temperatures to improve efficiency in the process or cycle or to help initiate particular chemical reactions. The European community is interested in the VR for producing high-temperature (>550°C) air.

Approach/Background:

During FY 1987, a metal wire mesh VR was developed and tested under International Energy Agency/Small Solar Power Systems (IEA/SSPS) Task VII. Sandia participated in the testing, which was conducted in Almeria, Spain, at the Plataforma Solar beginning in August 1987. Sandia prepared a computer model of the volumetric receiver for predicting and evaluating results. Sandia recently designed and fabricated a new volumetric receiver absorber to be tested at the Plataforma Solar using a porous ceramic material. This absorber was tested in May/June of 1989.

Status/Accomplishments:

VR testing thus far has demonstrated the feasibility of the concept for use in central receiver systems. The porous ceramic absorber designed and fabricated by Sandia was tested at the Plataforma in Spain. The results of the testing of the ceramic foam volumetric absorber demonstrated that the material will survive the high flux-high temperature environment. The thermal efficiencies of this absorber were relatively low (70%); however, the absorber design has not yet been optimized. The European PHOEBUS consortium is very interested in VRs for use in their proposed 30-MW_e central receiver power plant. Bechtel National has also performed a systems analysis and conceptual design of a VR as its contribution to the PHOEBUS consortium.

Currently, Sandia is working on the following tasks:

1. Optical characterization of absorber materials
2. Solar furnace testing of absorber materials and geometries
3. Development of a computer model of the volumetric receiver absorber
4. Design and testing of an optimized porous-ceramic absorber
5. Development and testing of air curtains for volumetric air receivers.

Major Project Reports:

Chavez, J. M., and C. Chaza, *Design, Fabrication and Testing of a Porous-Ceramic Absorber for Use in a Volumetric Air Receiver.*

Summary Date: October 1989

Wind Load Field Test Program

Project/Area/Task:
Structural Analysis

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: J. W. Grossman

Telephone: (505) 846-5482

Contractor: Cermak Peterka Petersen, Inc., Wind Engineering Consultants

Principal Investigator: J. W. Grossman

Telephone: (505) 846-5482

Contract Number: DE-AC04-76-DP00789

Contract Period: Ongoing

Contract Funding (Source):
FY 1989: $66,500 (DOE)
FY 1990: $150,000 (DOE)

Objective:

In the overall program to reduce heliostat costs, designers have been provided with design wind loads based solely on values derived from wind tunnel tests. This program was initiated to develop the capability to provide dynamics wind load measurements on solar concentrator structures, analyze the data for comparison with the existing load coefficients, and provide field-verified coefficients for the design guides for concentrators.

Approach/Background:

An existing heliostat pedestal at the Solar Thermal Test Facility was instrumented with strain gages and connected to a data-acquisition system in a test trailer adjacent to the pedestal. Meteorological data from an existing meteorological tower are also connected to the data acquisition. When desirable wind conditions exist, measurements are made for two-minute periods.

Status/Accomplishments:

Static load calibration tests were performed, and strains from low-level winds (<25 mph) were measured. The results of these tests are being evaluated by Sandia and Cermak Peterka Petersen, Inc., Wind Engineering Consultants.

Major Project Reports:

The program definition document was issued March 30. A status report will be issued when analysis of current data is completed.

Summary Date: October 1989

Receiver Thermal Testing

Project/Area/Task:
Distributed Receiver Technology/Receivers

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: A. A. Heckes

Telephone: (505) 844-3918

Contractor:
California State Polytechnic University
Kellog Unit Foundation
3801 W. Temple Avenue
Pomona, CA 91768

Principal Investigator: W. B. Stine

Telephone: (714) 869-2575

Contract Number: SNL 02-5759

Contract Period: 09/89 – 09/89

Contract Funding (Source):
FY 1987: $55,000 (DOE)
FY 1988: $20,000 (DOE)
FY 1989: $30,000 (DOE)

Objectives:

To quantify the various heat-loss mechanisms of a typical, cavity-type solar receiver, including heat conduction through the walls, convection from the aperture, and radiation from the aperture and walls. The losses are also quantified versus the temperature of the heat-transfer fluid and the inclined angle of the receiver. A wind tunnel was fabricated to measure heat loss versus wind velocity at various angles and wind speeds as high as 20 mph.

Approach/Background:

Measurements of temperature changes, plus heat and radiant energy fluxes, were performed on a typical Shenandoah-type receiver. Also, variations in heat losses were measured versus wind speed and direction for several receiver orientations.

Status/Accomplishments:

The contract was extended from September 30, 1988, to September 30, 1989. All data and analysis of heat losses in still air were completed. Two technical society papers were written, both of which are to be published as Sandia documents.

Major Project Reports:

Stine, W. B., and C. G. McDonald, *Cavity Receiver Convective Heat Loss, Proceedings of the 1989 International Solar Energy Society, Solar World Congress.*

Stine, W. B., and C. G. McDonald, *Cavity Receiver Heat Loss Measurements, Proceedings of the 1988 ASME Solar Energy Engineering Conference.*

Summary Date: 1989

Kinematic Stirling Engine Technology

Project/Area/Task:
Conversion Devices

Directing Organization:
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Project Manager: K. L. Linker

Telephone: (505) 846-7817

Contractor:
Stirling Thermal Motors, Inc. (STM)
2840 Boardwalk
Ann Arbor, MI 48104

Principal Investigator: T. Godett

Telephone: (313) 995-1755

Contract Number: SNL 53-8452

Contract Period: 07/86 – 12/89

Contract Funding (Source):
FY 1986: $299,950 (DOE)
FY 1987: -0- (---)
FY 1988: $5,000 (DOE)
FY 1989: $15,000 (DOE)

Objectives:

To demonstrate the STM kinematic Stirling engine for a dish-electric system that has near-term commercialization potential and meets DOE's performance and cost goals.

Approach/Background:

The kinematic Stirling cycle engine has been considered for several years as a near-term heat engine for the Solar Thermal Electric Technology dish-electric applications. In an effort to advance the Stirling technology toward longer life and commercialization, Sandia recently acquired an STM 25-kW kinematic Stirling engine, STM4-120, for evaluation. This engine was designed from the outset to be a long-life, commercial product engine.

Status/Accomplishments:

In FY 1988, STM demonstrated the engine at its facility and produced 23 kW of shaft power at a conversion efficiency of 40%. This measured power and efficiency agreed with the computer-modeling predictions for this engine. After operating approximately 50 years, STM delivered the engine to Sandia in September 1988 for further testing. Sandia has operated the STM4-120 at its engine test facility. The engine has operated for more than 20 hours and produced 7.4 kW of shaft power at a reduced pressure in the helium working fluid. Full-pressure tests are scheduled to begin in early FY 1990. In late FY 1990, a reflux heat-pipe or pool boiler receiver will be combined with this engine and tested on one of Sandia's test-bed concentrator dishes.

Major Project Reports:

Holtz, R. E., and K. L. Uherka, *Study of the Reliability of Stirling Engines for Distributed Receiver Systems.*

Summary Date: October 1989

Solar Energy Research Institute

Exploratory Research

Project/Area/Task:
Exploratory Research

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: D. Blake

Telephone: (303) 231-1202

Contractor:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: D. Blake

Telephone: (303) 231-1202

Contract Number: DE-AC02-83CH10093

Contract Period: 10/88 – 09/89

Contract Funding (Source):
FY 1989: $2,700,000 (DOE)

Objectives:

To establish the scientific base and understand the phenomena involved in effective use of the unique attributes of concentrated solar energy and to develop and demonstrate, in cooperation with industry, a capability for the industrial application of materials processing using concentrated solar radiation.

Approach/Background:

Enhance scientific understanding of photochemical effects by concentrated solar flux. Examine performance and potential of concentrated flux for materials processing.

Status/Accomplishments:

The availability of highly concentrated solar flux has long been thought to have value in the metallurgical and aerospace fields. The Solar Thermal Program has begun to explore the use of concentrated light to power lasers of desirable frequency for space power and communication and to explore the benefit of using solar flux in a broad set of possible applications that otherwise would involve large quantities of fossil fuels.

Optical and thermal methods are used to add value to materials in the form of improved performance (for example, corrosion, temperature, wear, and oxidation resistance) or for aesthetic reasons. Concentrated sunlight can provide high photon flux in the form of broad-band radiation that can induce photochemical processes or can provide rapid heating in controlled regions of a sample. Modification of an arbitrarily thin layer of a metallic or ceramic component's surface is widely practiced as a means of imparting properties required for a particular application without investing the energy required to modify the complete bulk of a part or having to use strategic materials for more than a small fraction of the total mass of a part. Work in the program has demonstrated phase transformation hardening of steel, formation of high-alloy surfaces on steel by fusion of powder coatings, rapid thermal annealing of thin film structures, and formation of hard coatings by reaction of metal surfaces with reactive gases using highly concentrated solar beams. Carbon fibers are used in high-performance materials. Research has demonstrated that oxidation resistance can be improved by passing the fiber through a concentrated solar beam.

System studies have shown that by using a solar furnace, the process can be cost competitive with lasers and high-intensity arc lamps.

Conventional solar energy applications use fluxes in the range of 1 sun to about 2000 suns. Historically, higher concentrations have been used exclusively to drive thermal processes, and lower levels have been used for low-grade heat and photon-driven processes such as photovoltaics and photochemistry. Work performed in the Solar Thermal Program has shown that it is possible to achieve concentrations in excess of 50,000 suns. This possibility can aid new applications that require very high temperatures, heating rates, or a large number of photons. A new solar furnace with a unique off-axis design is under construction at SERI.

Major Project Reports:

Fields, C. L., J. R. Pitts, J. T. Stanley, "Solar-Induced Surface Transformation of Materials" (SISTM).

Summary Date: October 1989

Photochemical Systems

Project/Area/Task:
Photochemical Systems

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: J. Anderson

Telephone: (303) 231-1022

Contractor:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

Principal Investigator: J. Anderson

Telephone: (303) 231-1022

Contract Number: DE-ACO2-83CH10093

Contract Period:
Ongoing multiyear research

Contract Funding (Source):
FY 1989: $1,775,000 (DOE)

Objectives:

To develop the technology required to field a project demonstrating solar-driven chemical processes with an emphasis on the destruction of hazardous chemicals. At least one pilot-scale experiment representing a commercially replicable solar hazardous chemical destruction process will be field tested by 1994.

Approach/Background:

Build and test a pilot-scale plant for detoxifying dilute aqueous waste. Build and test a pilot plant for high-temperature decomposition of hazardous chemicals by FY 1993.

Status/Accomplishments:

Work in photochemical systems was stepped up in FY 1989 because of the significant prospects of using solar thermal technology and concentrated sunlight in photochemically destroying toxic chemicals--thus not only providing the needed energy but also capitalizing on the unique attributes of sunlight. These attributes are the ultraviolet radiation and the high heating and quenching rates beneficial in conducting chemical reactions and controlling end products and the intermediate process.

The current efforts in solar photochemistry are aimed at solar detoxification processes. Two types of solar technology are being developed. The first is a process for the solar detoxification of water, a low-temperature, low-flux process for treating water contaminated with organic chemicals such as chlorinated hydrocarbons. This technology will offer an important new tool in addressing the large amount of contaminated water that needs treatment in the United States today. The primary conventional processes for handling this problem are air stripping and carbon adsorption. The solar process offers several advantages over these processes because it actually destroys the contaminants while they are in the water rather than simply transfer them to another medium.

The second technology under development is the solar detoxification of hazardous waste. This is a high-temperature, high-flux process that will address many of the same chemicals that are currently destroyed by incineration. The processes being explored use the direct irradiation of both the (gaseous) chemical itself and a porous substrate. The substrate will provide both heading and catalytic effect to enhance the speed and thoroughness of the chemical destruction. Successful tests have been run in both air and steam atmospheres. The advantages of this process over incineration include reduced air emissions, lower temperatures, and smaller energy consumption.

Major Project Reports:

Glatzmaier, G. C., M. S. Mehos, and R. G. Nix, "Reactor Design for Solar Chemistry."

Thornton, J. P., *Solar Thermal Technologies in Support of an Urgent, National Need--Opportunities for the Photon-Enhanced Decomposition of Concentrated and Dilute Hazardous Wastes.*

Summary Date: October 1989

Solar-Enhanced Chemical Reactions

Project/Area/Task:
Direct Conversion/Photoenhanced Chemical Reactions

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: R. G. Nix

Telephone: (303) 231-1757

Contractor:
University of Houston
Sponsored Program
4800 Calhoun Road
Houston, TX 77004

Principal Investigator: L. Vant-Hull

Telephone: (713) 749-1154

Contract Number: XX-7-07028-01

Contract Period: 03/87 – 03/01/90

Contract Funding (Source):
FY 1988: $260,000 (DOE)
FY 1989: $185,998 (DOE)

Objectives:

To experimentally investigate the solar enhancement of chemical reactions to identify those most amenable to solar enhancement and to assess the technical and economic feasibility of an industrially valuable chemical reaction system.

Approach/Background:

Break chemical bonds using high-flux solar radiation, analyze solar catalytic reactions, and research photoenhanced catalytic reactions.

Status/Accomplishments:

Experimentally investigated the solar enhanced decomposition of various hazardous waste materials to conclusively show the existence of significant solar effects.

Developed and experimentally validated a theoretical model to explain the observed solar effects.

Worked with SERI to initiate an assessment of the potential for practical application of solar-enhanced chemical reactions.

Major Project Reports:

Ekwelundu, E., and A. Ignatiev, "Electron-Stimulated Desorption from GaAs(100) Surface."

Ekwelundu, E., and A. Ignatiev, "Electron-Stimulated Desorption of O^+ Ions from a Gas Covered Cds-(0001) Surface."

Ekwelundu, E. C., and A. Ignatiev, "Electron-Stimulated Desorption of Positive Ions from an Adsorbate Covered Si(100) Surface."

Ekwelundu, E., and A. Ignatiev, "Photodesorption from CdS(0001) Exposed to NO and Co."

Moshfegh, A. Z., and A. Ignatiev, "Combined High-Pressure Photocatalytic Reactor—UHV System and Sample Transfer Device."

Nahar, N. M., G. H. Mo, and A. Ignatiev, "Development of an Al_2O_3 Selective Absorber for Solar Collectors."

Vant-Hull, L. L., "Solar Thermal Central Receivers."

Vant-Hull, L. L., "Solar Thermal Electricity, An Environmentally Benign and Viable Alternative."

Wentworth, W. E., and C. Batten, *Solar Enhanced Chemical Reactions.*

Wentworth, W. E., C. F. Batten, and W. Gong, "Evaluation of Photo-Contribution to a Chemical Reaction Using Concentrated Solar Energy."

Wentworth, W. E., C. F. Batten, and W. Gong, "The Photo-Assisted Thermal Decomposition of Methanol and Isopropanol in a Fluidized Bed."

Summary Date: October 1989

Solar Incineration of Hazardous Wastes

Project/Area/Task:
Energy Conversion Technology/Direct Conversion Research

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: R. Nix

Telephone: (303) 231-1757

Contractor:
University of Dayton
Research Institute
300 College Park
Dayton, OH 45469

Principal Investigator: B. Dellinger

Telephone: (513) 229-2846

Contract Number: XX-6-06082-01

Contract Period: 09/84 – 02/28/90

Contract Funding (Source):
FY 1984: $105,000 (DOE)
FY 1985: -0- (---)
FY 1986: $100,000 (DOE)
FY 1987: -0- (---)
FY 1988: $123,000 (DOE)
FY 1989: $190,594 (DOE)

Objectives:

To perform a chemical kinetic investigation of the thermal decomposition process, i.e., the destruction rate as a function of time, temperature, and intensity of solar flux. To determine the performance merits of pyrolysis relative to oxidation and to understand the role and extent of the formation of products of incomplete combustion (PIC) in the solar detoxification of hazardous waste. To achieve a field confirmation of the observed laboratory phenomena with the confirmation in the actual solar environment.

Approach/Background:

Investigate the excited state thermal/photolytic process, study mechanistically the PIC formation under oxidative and pyrolytic conditions, and conduct solar detoxification tests.

Status/Accomplishments:

Experimentally investigated the solar enhancement of heterogeneous catalytic reactions of hydrocarbons to show significant improvements for both reforming and cracking reactions.

Supported the field testing by SERI and chemical analysis to show that dioxin can be destroyed to six-nines (99.9999%) or greater.

Major Project Reports:

Dellinger, B., J. L. Graham, and K. A. Bauchert, "Solar Thermal/Photolytic Destruction of PCBs."

Summary Date: October 1989

Wind Load Reduction Research

Project/Area/Task:
Collection Technology/Concentrator Research

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: M. Carasso

Telephone: (303) 231-1353

Contractor:
Colorado State University
Department of Civil Engineering
Fort Collins, CO 80523

Principal Investigator: J. Peterka

Telephone: (303) 491-8344

Contract Number: XX-6-06034-1

Contract Period: 02/86 – 12/89

Contract Funding (Source):
FY 1986: $46,000 (DOE)
FY 1987: $48,700 (DOE)
FY 1988: $45,000 (DOE)
FY 1989: $45,000 (DOE)

Objectives:

To identify, evaluate, and demonstrate the technical feasibility of innovative concepts for avoiding or reducing the wind loads on concentrating collectors.

Approach/Background:

Study the moment loads on parabolic dishes in field environments to find methods to reduce load magnitudes and measure local pressure distributions on parabolic dish collectors for single and in-field units to determine the extent of nonuniformity of wind loading.

Status/Accomplishments:

Wind tunnel tests continue to explore the wind loads on dishes in particular orientations and field conditions that result in unexpectedly high moments in azimuth about the pedestal.

Major Project Reports:

Peterka, J. A., Z. Tan, B. Bienkiewicz, and J. E. Cermak, *Wind Loads on Heliostats and Parabolic Dish Collectors.*

Summary Date: October 1989

Compound Optical Systems with Maximal Concentration for Solar Thermal Conversion

Project/Area/Task:
Collection Technology/Concentrator Research/ Innovative Concepts

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: A. Lewandowski

Telephone: (303) 231-1972

Contractor:
University of Chicago
Research Administration
970 E. 58th Street
Chicago, IL 60637

Principal Investigator: J. O'Gallagher

Telephone: (312) 702-7757

Contract Number: XK-4-04070-03

Contract Period: 01/85 – 12/88

Contract Funding (Source):
FY 1984: $77,127 (DOE)
FY 1985: -0- (---)
FY 1986: $67,500 (DOE)
FY 1987: $50,000 (DOE)
FY 1988: $32,000 (DOE)

Objectives:

To analyze the general optical performance features of nonaxisymmetric primary concentrators that are not axisymmetric, to develop a computer-based simulation model for characterizing their performance, and to explore the optical design and performance impacts of using nonimaging secondary concentrators with such configurations.

Approach/Background:

Determine specific code requirements (with SERI), develop and test a computer code for implementing the model, apply the model to evaluate (with SERI) selected candidate configuration designs, prepare a written description of the model and documentation of the computer code, deliver the computer code to SERI, and provide consultation and support to SERI users.

Status/Accomplishments:

A ray-trace computer code was developed, tested, and validated for analysis of nonaxisymmetric point-focus concentrators. The code was used to assess the impact on performance of nonimaging secondary concentrators when used in tandem with nonaxisymmetric primary concentrators.

Major Project Reports:

O'Gallagher, J., and R. Winston, *Optical and Thermal Performance Characteristics of Two-Stage Dish Concentrators with Non-Paraboloidal and Non-Axisymmetric Membrane Primaries.*

Summary Date: October 1989

Design and Fabrication Support for the High-Flux Solar Furnace

Project/Area/Task:
Collection Technology/Concentrator Research/Innovative Optics

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: A. Lewandowski

Telephone: (303) 231-1972

Contractor:
Advanced Thermal Systems, Inc.
7600 East Arapahoe Rd., Suite 215
Englewood, CO 80112

Principal Investigator: D. Gorman

Telephone: (303) 721-8411

Contract Number: BX-9-19093-1

Contract Period: 09/89 – 2/90

Contract Funding (Source):
FY 1989: $75,000 (DOE)

Objective:

To provide design and fabrication support for various components needed at the high-flux solar furnace.

Approach/Background:

Support activities include conceptual, preliminary, and detailed design; fabrication; installation; and checkout.

Status/Accomplishments:

Design and fabrication activities for a unique attenuator concept for the high-flux solar furnace at SERI were initiated late in the fiscal year.

Major Project Reports: None

Summary Date: October 1989

Regenerative Thermoelectrochemical Converter (RTEC) Power Module

Project/Area/Task:
Heat Engines/Heat Engine Technology

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: M. Carasso

Telephone: (303) 231-1353

Contractor:
Hughes Aircraft Company
Electro Optical Data Systems Group
2000 East El Segundo Blvd.
El Segundo, CA 90245

Principal Investigator: J. McHerdy

Telephone: (213) 616-8674

Contract Number: ZX-8-07057-1

Contract Period: 12/87 – 01/90

Contract Funding (Source):
FY 1988: $473,600* (DOE)
FY 1988: $118,400* (Hughes)
FY 1989: $178,800* (DOE)
FY 1989: $ 44,700* (Hughes)

Objectives:

To perform sufficient experimental research on each component to define a basic system configuration, understand its performance, and enable a reasonable estimate of its eventual cost and ultimate performance. To validate the system concept by operating a laboratory closed-loop system. To establish a technology base that will support the eventual engineering development of RTEC. To provide a basis for determining the extent to which RTEC can contribute to achieving the Solar Thermal Technology Program goals. To achieve a minimum efficiency of 30% at a minimum current density of 50 mA/cm^2 with a definition of how to improve the system to later accomplish 40% efficiency at a current density of 200 mA/cm^2.

*Costs are shared; the DOE share includes funds from FY 1986 and FY 1987.

Approach/Background:

Provide research on electrochemical cell components, stripper components, condenser components, integrated systems, and materials and develop an engineering assessment and technology data base.

Status/Accomplishments:

A number of RTEC cells were tested at the Hughes Company using a large number of different membranes. The performance of a DOW Chemical electrode/membrane, which allows the hydrogen to bypass the membrane, showed the best performance, exceeding expectations. Condenser tests were successfully completed.

A major challenge to demonstrating the technical feasibility of the concept was overcome at SERI with the fabrication of a smoothly performing RTEC regenerator and the delivery of the regenerator for assembly into a Hughes closed-loop demonstration in FY 1990.

Major Project Reports: None

Summary Date: October 1989

Industrial Support on Silver-Polymer Research and Development

Project/Area/Task:
Materials/Silver-Polymer Research

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: P. Schissel

Telephone: (303) 231-1226

Contractor:
3M Company
3M Center Building, 207-1W
St. Paul, MN 55144

Principal Investigator: B. Benson

Telephone: (612) 733-1031

Contract Number: ZX-8-07233-1

Contract Period: 01/87 – 10/89

Contract Funding (Source):
FY 1988: $40,000 (DOE)
FY 1988: $40,000 (3M)
FY 1989: $40,000 (DOE)
FY 1989: $40,000 (3M)

Major Project Reports: None

Summary Date: October 1989

Objective:

To develop a weatherable silver solar reflecting film with a reflectance of 95%.

Approach/Background:

Develop the silver solar reflecting film to a reflectance of 95%, which includes preparing and testing a substantial number of product constructions, building on previous results.

Status/Accomplishments:

Investigated methods for higher ultraviolet resistance in the film. Tested samples prepared from different materials and with different ultraviolet absorbers. Achieved good ultraviolet resistance. A new product based on these results was announced by the 3M Company.

Protective Treatments for Membrane Heliostat Mirrors

Project/Area/Task:
Materials/Silver-Polymer Research

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: P. Schissel

Telephone: (303) 231-1226

Contractor:
Springborn Materials Science, Inc.
10 Springborn Center
Enfield, CT 06082-4899

Principal Investigator: B. Baum

Telephone: (203) 749-8371

Contract Number: XX-9-19028-1

Contract Period: 10/87 – 08/89

Contract Funding (Source):
FY 1988: $24,949 (DOE)
FY 1989: $29,350 (DOE)

Objectives:

To evaluate and recommend a coating to provide soil resistance on mirrors.

Approach/Background:

Apply commercial coatings on polymer and glass mirrors, and examine their soil-resistant properties.

Status/Accomplishments:

Completed work on applying soil-resistant coatings on glass and acrylic surfaces. Coated acrylic and glass surfaces with Owens Illinois Glass Coat 651 hard coating and overcoated with Petrarch T2492 fluorosilane, which improved the soil resistance of both the untreated acrylic and the untreated glass. Found five formulations to be optically clear, have good adhesion, and offer better resistance to soiling than untreated glass.

Major Project Reports: None

Summary Date: October 1989

Composite Materials for Heliostats

Project/Area/Task:
Systems and Applications

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: L. M. Murphy

Telephone: (303) 231-1050

Contractor:
University of California at Berkeley
c/o Sponsored Projects Office
University of California
Berkeley, CA 94720

Principal Investigator: H. Dharan

Telephone: (415) 642-4933

Contract Number: XX-6-06019-01

Contract Period: 09/86 – 08/89

Contract Funding (Source):
FY 1986: $97,715 (DOE)
FY 1987: $98,644 (DOE)
FY 1988: $103,641 (DOE)
FY 1989: $97,229 (DOE)

Objectives:

To define the feasibility of composite materials for heliostat and solar concentrator applications and to contribute to the current understanding of the response of complex laminates to long-term creep and thermal cycling.

Approach/Background:

Analyze the state of the art in heliostat design (materials, processes, and structural technology) to identify the important issues for improving performance and reducing cost. Study the application of composite materials to stretched-membrane heliostat design, and identify areas where weight and cost savings have high potential. Construct a finite-element model of the stretched-membrane heliostat (structure and membrane) using a nonlinear finite-element analysis program such as ANSYS. Develop processes for manufacturing samples of composite substrate membranes, and analyze ring structural elements that meet the requirements by model. Construct 1-m-diameter prototypes of composite stretched-membrane heliostat designs, and subject them to structural and accelerated life testing.

Status/Accomplishments:

Definitively investigated the application of composite materials to stretched-membrane heliostats to show that the composite materials used for both the membrane and the frame exhibit significant advantages over metals. These advantages include high strength-to-weight design, higher resistance to wind-induced deformation, the possibility of independently tailoring bending and torsional stiffness, and better transportability.

Major Project Reports:

Kiang, H. J., and C. K. H. Dharan, "Analyses of Composite Stretched-Membrane Heliostats."

Summary Date: October 1989

Methods for Achieving Extremely High Solar Flux Concentrations

Project/Area/Task:
Exploratory Research/Innovative Optics

Directing Organization:
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401

Project Manager: B. Gupta

Telephone: (303) 231-1760

Contractor:
University of Chicago
Office of Research Administration
970 E. 58th Street
Chicago, IL 60637

Principal Investigators: R. Winston,
J. O'Gallagher

Telephone: (312) 962-7756/7757

Contract Number: XX-6-06019-02

Contract Period: 08/86 – 08/89

Contract Funding (Source):
FY 1986: $63,902 (DOE)
FY 1987: $75,705 (DOE)
FY 1988: $75,393 (DOE)
FY 1989: $65,000 (DOE)

Objectives:

To construct a prototype-scale model of an optical system for achieving very high flux in a refractive medium with the highest practical index of refraction. To develop sensors and techniques for measuring very high solar flux in the range of 50,000-80,000 suns and beyond. To test and evaluate the scale prototypes and the sensors in the laboratory. To investigate the conversion of sunlight to laser light by designing and building a laser cavity and select materials for solar end pumping that will demonstrate high conversion efficiency.

Approach/Background:

Investigate the conversion of sunlight to laser light by using a secondary concentrator and the excitation of crystals with the highly concentrated solar flux. Investigate the doubling of frequency through optical techniques.

Status/Accomplishments:

Several experiments were conducted using YAG crystals for end pumping and obtained lasing with concentrated sunlight. Improvements in concentrated solar flux density were made by achieving a flat heliostat surface and high reflectance and a good-quality secondary. The secondary and laser materials were prepared for high-flux laser experiments.

Major Project Reports: None

Summary Date: October 1989

Current Publications

Sandia National Laboratories

Adkins, D. R., 1989, "Design Considerations for Heat-Pipe Solar Receivers," *Proceedings of the 11th Annual Solar Energy Conference*, San Diego, CA, April 2-5.

Adkins, D. R., 1988, *Analysis of Heat Pipe Receivers for Point-Focus Solar Concentrators*, SAND-88-0093, Albuquerque, NM: Sandia National Laboratories.

Alpert, D. J., and R. M. Houser, *Evaluation of the Optical Performance of a Prototype Stretched Membrane Mirror Module for Solar Control Receivers*, 1989, SAND88-1876J, Albuquerque, NM: Sandia National Laboratories. Also in 1989, *Journal of Solar Energy Engineering*, Vol. 3.

Alpert, D. J., D. K. Johnson, R. M. Houser, L. Yellowhorse, and J. VanDerGeest, 1988, *Optical Performance of the First Prototype Stretched-Membrane Mirror Modules*, SAND88-2620, Albuquerque, NM: Sandia National Laboratories.

Andraka, C. E., and J. B. Moreno, 1989, *Pool Boiler Reflux Solar Receiver for Stirling Dish-Electric Systems*, SAND89-1311C, Albuquerque, NM: Sandia National Laboratories. Also presented at the 24th IECEC Meeting, Paper No. 899462, Washington, DC, August 1989.

Andraka, C. E., and J. B. Moreno, 1988, *Reflux Heat-Pipe Solar Receivers for Dish-Electric Systems*, SAND87-2976C, Albuquerque, NM: Sandia National Laboratories. Also presented at the 23rd IECEC Meeting, Paper No. 899213, Denver, Colorado, August 1988.

Ashley, C. S., S. T. Reed, and A. R. Mahoney, 1988, "Planarization of Metal Substrates for Solar Mirrors," *Material Research Society Symposium Proceedings*, Vol. 121.

Cameron, C. P., 1989, *Small Community Solar Experiment #2 Module Test Results*, SAND88-2802, Albuquerque, NM: Sandia National Laboratories, forthcoming.

Cameron, C. P., and V. E. Dudley, 1989, *Small Community Solar Experiment #1 Module Test Results*, SAND88-2803, Albuquerque, NM: Sandia National Laboratories, forthcoming.

Chavez, J. M. and C. Chaza, 1989, *Design, Fabrication and Testing of a Porous-Ceramic Absorber for Use in a Volumetric Air Receiver*, Albuquerque, NM: Sandia National Laboratories. Also prepared for 1990 MAES Conference, Albuquerque, NM, March 28-30, 1990.

Chavez, J. M., D. K. Johnson, C. E. Tyner, and W. A. Couch, *Water Flow Testing of the Direct Absorption Receiver Concept*, SAND88-3390, Albuquerque, NM: Sandia National Laboratories, forthcoming.

Development of a Low-Cost Drive Tracking Mechanism for Solar Heliostats or PV Arrays, Peerless-Winsmith, Inc. (contractor published report), Albuquerque, NM: Sandia National Laboratories.

Design and Demonstration of an Improved Stretched-Membrane Heliostat, 1989, Solar Kinetics, Inc., SAND89-7028, Albuquerque, NM: Sandia National Laboratories.

Diver, R. B., J. D. Fish, R. Levitan, M. Levy, E. Meirovitch, H. Rosin, S. A. Paripatyadar, and J. T. Richardson, *Solar Test of an Integrated Sodium Reflux Heat-Pipe Receiver/Reactor for Thermochemical Energy Transport*, SAND89-1672J, Albuquerque, NM: Sandia National Laboratories. Also submitted to *Solar Energy*.

Dhooge, P. M., 1989, *An Effluent Analysis System Design for Sandia National Labortories SOLTOX Facility*, Delphi Research, Inc., Albuquerque, NM 87102.

Hogan, R. E., and R. D. Skocypec, 1989, *Analysis of Catalytically Enhanced Solar Absorption Chemical Reactors: I - Basic Concepts and Numerical Model Description, II - Predicted Characteristics of a 100 kW Reactor*. To be published in the Proceedings of the December 1989 ASME Meeting.

Holmes, J. T., and C. A. Haslund, 1989, *A Solar Photochemical Process for Destroying Organics in Water*, SAND88-1235C, Albuquerque, NM: Sandia National Laboratories. Also presented at DOE/Model Conference, October 1989.

Holtz, R. E., and K. L. Uherka, 1988, *Study of the Reliability of Stirling Engines for Distributed Receiver Systems*, SAND88-7028, Albuquerque, NM: Sandia National Laboratories.

Keehan, K., and J. T. Richardson, 1989, *Carbon Monoxide Rich Methanation Kinetics on Supported Rhodium and Nickel Catalysts*, SAND88-7149, Albuquerque, NM: Sandia National Laboratories, forthcoming.

Khalili, K., T. Godett, and R. J. Meijer, 1989, *Design and Testing of a Heat Pipe Gas Combustion System for the STM4-120 Stirling Engine*, Albuquerque, NM: Sandia National Laboratories. Also in *Proceedings of the 24th Intersociety Energy Conversion Engineering Conference*, Paper No. 899540, Washington, DC, August 6-11, 1989.

Kolb, G. J., and C. W. Lopez, 1988, *Reliability of the Solar One Plant during the Power Production Phase (August 1, 1984 through July 31, 1987)*, SAND88-2664, Albuquerque, NM: Sandia National Laboratories.

Kolb, G. J., D. J. Alpert, and C. W. Lopez, 1989, *Insights from the Operation of Solar One and Their Implications for Future Control Receiver Plants*, SAND89-1532J, Albuquerque, NM: Sandia National Laboratories.

Kolb, G. J., D. Neary, and M. R. Ringham, 1988, *Demonstration of PC-Based Dynamic Simulation Models of Solar Thermal Systems*, SAND88-1299C, Albuquerque, NM: Sandia National Laboratories.

Kolb, G. J., D. Neary, M. R. Ringham, and T. L. Greenlee, 1989, *Dynamic Simulation of a Molten-Salt Solar Receiver*, SAND88-2895, Albuquerque, NM: Sandia National Laboratories.

Mancini, T. R., C. P. Cameron, and V. R. Goldberg, *NASA SCAD Concentrator Terrestrial Testing Feasibility Study*, Albuquerque, NM: Sandia National Laboratories, forthcoming.

Mavis, C. L., 1989, *A Description and Assessment of Heliostat Technology*, SAND87-8025, Albuquerque, NM: Sandia National Laboratories.

Mechanical Technology Incorporated, Conceptual Design of an Advanced Stirling Conversion System for Terrestrial Power Generation, 1988, NASA CR-180890, NASA/Lewis Research Center, Mechanical Technology, Inc., Albuquerque, NM: Sandia National Laboratories.

Menicucci, D., R. Hewett, and A. Poore, *Solar Thermal Design Assistance Center*, SAND89-1129, Albuquerque, NM: Sandia National Laboratories.

Moreno, J. B., and C. E. Andraka, 1989, *Test Results from Bench-Scale Sodium-Pool-Boiler Solar Receiver*, SAND89-0899, Albuquerque, NM: Sandia National Laboratories, forthcoming.

Neary, D. T., and M. R. Ringham, *A Dynamic Simulator/Analyzer for the Central receiver Test Facility (User's Manual)*, ESSCOR Corporation (unpublished contractor report), Albuquerque, NM: Sandia National Laboratories.

Pacheco, J. E., and J. T. Holmes, *Falling-Film and Glass-Tube Solar Photocatalytic Reactors for Treating Contaminated Water*, SAND88-2726C, Albuquerque, NM: Sandia National Laboratories. Also presented at American Chemical Society Meeting, Atlanta, GA, May 1989.

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Printed in the United States of America
Available from:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

Price: Microfiche A01
Printed Copy A05

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Prepared for the
U.S. Department of Energy
Assistant Secretary, Conservation and Renewable Energy
Washington, D.C. 20585

Prepared by the
Solar Technical Information Program
Solar Energy Research Institute
Golden, CO 80401-3393
Under Contract No. DE-AC02-83CH10093

DOE/CH10093-61
DE89009476
January 1990