SOLAR ♦ THERMAL ♦ ELECTRIC

Quarterly Progress Report

Fourth Quarter, FY96

October 1996

SOLAR•THERMAL•ENERGY

Sun♦Lab

Sandia National Laboratories, Albuquerque, NM
National Renewable Energy Laboratory, Golden, CO

Operated for the United States Department of Energy

SUMMARY OF ACCOMPLISHMENTS: FOURTH QUARTER FY96

Significant progress toward program goals and objectives was made during the quarter. Following are selected highlights. Details can be found in the body of the report.

Solar Two

- We resolved the heat-trace problems and are in the process of replacing defective circuits.
- We developed a new Test and Evaluation Plan that allows concurrent power production and testing.

Dish/Engine Joint Venture Programs

- Cummins operated a dish/Stirling system on the Georgia Tech campus during the 1996 Summer Olympic Games.
- Cummins suspended its solar division activities.

Manufacturing and Technical Support

- We worked with Daggett Leasing Corporation to identify the cause of its coking problem.
- We began work to train the Daggett Leasing operators on field alignment.
- The solar thermal presentations in Mexico were completed.

SolMaT

- SAIC started Phase 2 of its Heliostat Manufacturing project.
- Rockwell started Phase 2 of its Central Receiver Manufacturing project.
- McDonnell Douglas held a mid-term review of its Concentrator Component Manufacturing project.

Systems and Markets Analysis

- We performed an economic analysis of hybrid STE technologies that looked at the cost of using STE technologies to reduce CO_2 emissions.
- We established a contract to develop a new low emissivity heat collection element.
- We completed and distributed the second Interim O&M Cost Reduction Study Report.

Concentrator Technology

- The prototype Video SHOT system was completed.
- We conducted a final version of the SKI/AlliedSignal project.

Power Tower Technology

- Sun♦Lab supported the Solar Two project by assisting with heat trace refurbishment, conducting a corrosion survey, and preparing for the test and evaluations phase.
- The second-year activities of the Rockwell CRADA to develop an advanced molten salt receiver have begun, but are scaled back from the original plan.
- Plans have been made to test an advanced receiver panel at the NSTTF.

Dish Conversion Technology

- We completed fabrication, processing, and integration of the Thermacore heat-pipe receiver for the STM 4-120 Stirling engine. Performance mapping will be completed next quarter.
- We developed design tools for a hybrid heat-pipe receiver and correlated the tools with test results.

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INTRODUCTION

A need for new electric generating capacity, a heightened awareness of the environmental impacts associated with energy generation and use, and increased attention to energy efficiency will lead to a greater demand for solar thermal electric and other alternative energy technologies in the years ahead.

To date, over 350 MW_e of solar thermal electric systems have been installed in the United States, representing over 90% of the world's installed solar capacity. This power meets the needs of over 350,000 people and annually displaces the energy equivalent of 2.3 million barrels of oil. In addition, key cooperative joint ventures representing a 50/50 cost share between the federal government and the private sector have been established for power tower, parabolic dish/engine, and parabolic trough technologies. These joint ventures, valued at more than $150 million, strengthen the partnership among industry, utilities, and users. They are some of the current steps being taken to reduce levelized energy costs from solar thermal electric plants to between 6 and 10 cents per kilowatt-hour, thus leading to direct competition with conventional technologies.

OUR VISION

Our vision for solar thermal electric technology is the large-scale acceptance and installation of U.S.-designed and U.S.-manufactured solar thermal electric systems operating worldwide by early in the next decade. We expect to realize this vision through a coordinated program of joint venture projects, technology development and validation, and market conditioning.

OUR MISSION

The mission of the Solar Thermal Electric Program is to work with current and potential manufacturers and users of solar thermal electric technology to

- develop reliable and efficient solar thermal electric systems for generation of economically competitive power that can contribute significantly to the national energy mix and thereby reduce our dependence on imported energy sources,
- increase acceptance of this technology as a candidate for cost-competitive modular power generation by utilities, industry, and other user groups, both in the United States and abroad, and
- aggressively support the development of the industrial base required for this technology to penetrate a variety of energy applications and markets, creating new jobs and business opportunities for U.S. industry.

OUR STRATEGY

The Solar Thermal Electric Program strategy is consistent with the objectives set forth by the Department of Energy (DOE) in *Solar 2000—A Collaborative Strategy.*[1] The DOE and Sun♦Lab (a cooperative activity of Sandia National Laboratories and the National Renewable Energy Laboratory) will

- increase, through cooperative ventures, industrial participation in both the planning and execution of program elements. Specifically,
  - — the Solar Two molten-salt power tower project led by Southern California Edison will provide the technical base for the first commercial power tower plants.
  - — the Cummins Power Generation, Inc. (Cummins) 7-kW_e dish/Stirling system, designed for both remote and grid-connected applications, will be operated at utility and industrial sites.
  - — Science Applications International Corporation and Cummins, operating through the Utility Scale Joint Venture Program, will field 25-kW_e dish/Stirling systems, with the last phase of this program resulting in at least one megawatt of dish/engine system capacity installed by utilities.
  - — the SolMaT initiative will continue to support development of improved manufacturing capabilities for heliostats and other components to reduce costs in near-term markets.
- utilize the analytical and experimental capabilities of the program to support and enlarge the solar thermal technology base and our user, supplier, and decision-making constituency. Specifically,

[1] *SOLAR 2000—A Collaborative Strategy*, Office of Solar Energy Conversion, United States Department of Energy, Washington, D.C., February 1992.

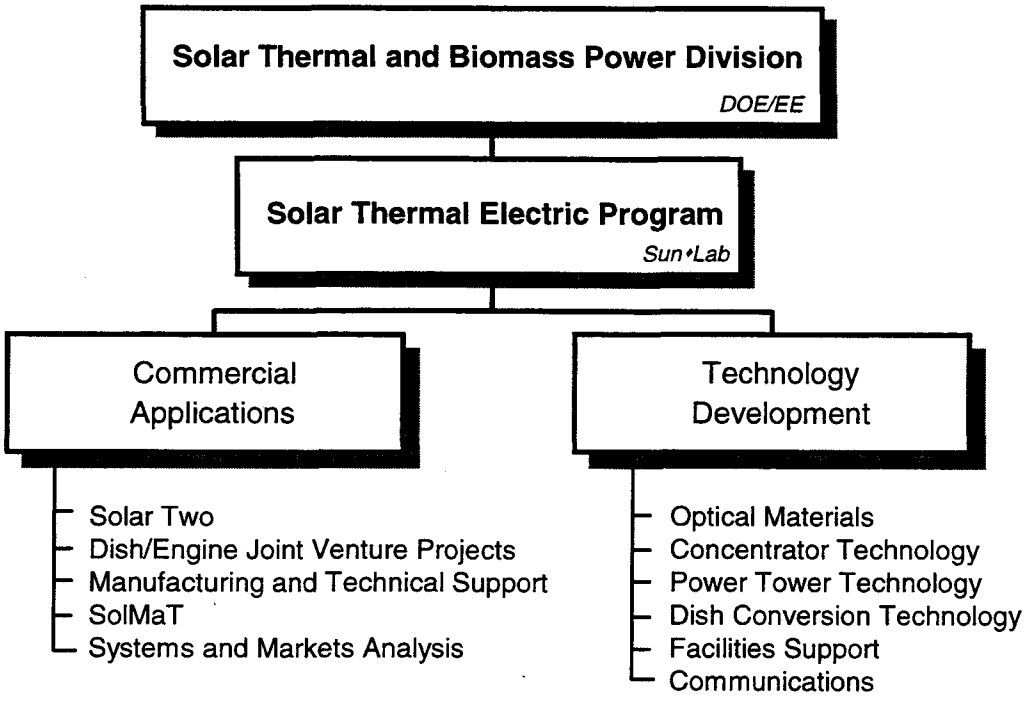
— industry/laboratory teams will extend the performance and reliability of critical system components (concentrators, receivers, optical materials, etc.) through focused research and development.

— industry and user requests for assistance will be addressed by the Solar Thermal Manufacturing and Technical Support program and other program resources.

— information exchange through conferences, road shows, and publications will be used to bring the technology to the attention of regulators, potential users, and the public.

OUR MANAGEMENT STRUCTURE

Specific implementation of the Solar Thermal Electric Technology Program is assigned to two field laboratories, Sandia National Laboratories in Albuquerque, New Mexico, and the National Renewable Energy Laboratory in Golden, Colorado. Sandia National Laboratories is the program's lead laboratory. Together, these two field laboratories are responsible for implementing the research and development plans that have been formulated to meet the objectives of the program. Activities are conducted both in-house at the laboratories and through subcontracts placed with private industry, other research organizations, and universities.



I. COMMERCIAL APPLICATIONS

The Solar Thermal Electric Program emphasizes two major categories of modular solar thermal technology: power towers (central receiver systems) and parabolic dish/engine systems. These two types of systems can satisfy utility needs for capacities ranging from a few kilowatts up to hundreds of megawatts. We also support parabolic trough system operations to help reduce operation and maintenance costs of future plants.

The program focuses on cost-shared activities led by industry. These government/industry partnerships represent teams uniquely qualified to rapidly advance the technology. The partnerships combine the manufacturing, marketing, and management skills of industry with the solar-specific experience base and analytical and experimental capabilities of Sun♦Lab. Presently, five major 50/50 cost-shared cooperative activities are underway within the program with a total value of more than $160 million. The following organizations are the private sector leaders of these joint activities:

- Southern California Edison and a consortium of other utilities and industry partners (Solar Two).
- Cummins Power Generation, Inc. and Science Applications International Corporation (dish/engine systems).
- KJC Operating Company (trough system operation and maintenance cost reduction).
- Science Applications International Corporation, Solar Kinetics, Inc. (heliostats), and Rockwell International Corporation (central receivers) (SolMaT).

A. SOLAR TWO

The goal of this project is to advance the near-term commercialization of solar power tower electricity generating facilities. The components for a power tower plant have been proven through testing and analysis. The next step in the commercialization of the technology is to design, construct, and operate a demonstration plant of a size that is large enough to reduce to acceptable levels the risks (technological and economic) of building the first commercial plant.

A consortium of U.S. utility concerns led by Southern California Edison Company (SCE) is conducting a cooperative project with the U.S. DOE and industry to convert the 10-MW_e Solar One Central Receiver Pilot Plant to utilize molten-nitrate-salt technology. Successful design, construction, and operation of the converted plant, called Solar Two, will reduce the economic risks of building the initial commercial power tower projects and accelerate their commercial acceptance. Joining SCE and the DOE in sponsoring this project are the following organizations: Los Angeles Department of Water and Power, Idaho Power Company, PacifiCorp, Sacramento Municipal Utility District, Arizona Public Service Company, Salt River Project, California Energy Commission, Electric Power Research Institute, South Coast Air Quality Management District, Bechtel Corporation, Rockwell International Corporation, and Nevada Power Corporation. Sandia chairs the project's Technical Advisory Committee (TAC) and supports the DOE in technically monitoring the project. The Solar Two Project converted the Solar One heat transfer system from water/steam to molten nitrate salt by replacing the water/steam receiver and oil/rock thermal storage systems with nitrate-salt receiver, thermal storage, and steam generator. The estimated cost of Solar Two, including its three-year test period, is $48.5 million.

Status

Effort this quarter was focused on repairing the plant after the receiver tube rupture described in the 1996 third quarterly report.

Accomplishments

Startup, Checkout, and Acceptance

- The salt systems were flushed to remove corrosion scale.
- Pipe integrity was verified.
- The ruptured tube was replaced.
- The salt-system heat trace was redesigned and replaced.
- A strainer was added to the salt riser to protect the receiver.
- Heat trace was placed back into service.

Test and Evaluation

- A new Test and Evaluation (T&E) Plan was developed that allows for concurrent power production and testing.
- A Baseline Test was planned that will commence after plant acceptance. This test is designed to obtain data that requires the plant to be in special operating configurations. The Baseline Test will last for about 25 days. All other tests will be performed in parallel with power production over the entire course of routine operation (one to two years).
- An evaluations team was formed. This team will track high-level information related to (1) plant performance in comparison to prediction; (2) availability, maintainability, and forced outages; (3) controllability; and (4) equipment lifetime.
- New high-speed computers were installed on-site to support T&E.
- A data archive system was developed and implemented. Data will be archived on CDs.

Operations and Maintenance

- No change since last quarter.

Programmatic

- A Steering Committee meeting was held on July 18. SCE presented details on the pricing methodology that will be used for the project's power sales (Standard Offer 1). Also, details of the tube rupture were presented and the use of Solar Two for astrophysics research was discussed.
- The TAC held its quarterly meeting on September 18. Status of the reconstruction activity was discussed and a revised schedule was presented. The issue of Failure Modes Analysis (FMA) was discussed. FMA will be revisited to accommodate insight that has been gained during startup and the as-built configuration of the plant and control systems. The TAC will be involved in a review of the revised FMA.

Sun♦Lab Support

Sun♦Lab provided

- assistance and quality control related to the new heat trace design and installation.
- guidance on plant improvements to be made during the outage related to pipe supports, instrumentation, and so forth.
- a survey of the heliostat field to identify area lost because of corrosion and the extent of mirror delamination.
- data handling software for analyzing the plant and reporting important summary information (e.g., power generated, energy collected, energy stored, weather conditions, and other information) on a daily basis.
- the plans for the T&E activities.

Planned Activities for Next Quarter

- We will return the plant to service.
- We will perform acceptance testing.
- We will turn over the plant to SCE for operation.

Issues

- Issues remain related to financial responsibility for the outage. These issues should be resolved in the months to come.

Major Milestones

Milestone	Planned	Actual
Plant acceptance; initiation of operations.	Feb 96 *Delayed.*	
Formal dedication of Solar Two.	Jun 96	Jun 96

Resources ($k)

	Sandia	NREL	DOE	Total
FTE Costs	603	85	0	**688**
Contracts	59	50	1,500	**1,609**
Total	**662**	**135**	**1,500**	**2,297**

B. DISH/ENGINE JOINT VENTURE PROJECTS

The objective of the dish/engine cooperative projects is to commercialize dish/engine solar thermal electric systems. The approach is to form joint ventures with industry, utilities, and other users. The Dish/Stirling Joint Venture Program (DSJVP) with Cummins Power Generation, Inc., underway since 1991, will develop a 7-kW$_e$ dish/Stirling system primarily for remote application. Two Utility Scale Joint Venture Program (USJVP) contracts with Science Applications International Corporation (SAIC) and Cummins will develop 25-kW dish/Stirling systems for utility application.

DSJVP & Cummins USJVP

Status

In May, Sandia transferred its DSJVP and USJVP contracts to Cummins Renewable Energy Company (CREC), a new organization that would be owned by Cummins Engine Company and a number of investors. On June 30, Cummins Engine Company suspended its solar division activities in Abilene, Texas. Unfortunately, Cummins was unable to close the deal with the potential investors, and all activity has been stopped. Close out of the Cummins USJVP and DSJVP contracts has been initiated.

In late September, the assets of the Cummins solar operations in Abilene, Texas, were sold to Kombassan, a Turkish holding company. Kombassan intends to ship the equipment back to Turkey and commercialize the technology there.

Cummins was able to install and demonstrate a dish/Stirling system at the 1996 Olympic Games on the Georgia Tech campus in Atlanta, Georgia.

Accomplishments

- Cummins operated a dish/Stirling system on the Georgia Tech campus and site of the 1996 Olympic Games. In September, the system was removed and the site restored.
- The concentrator at the Central and South West Services, Inc. test site in Ft. Davis, Texas, was removed. Most of the Sandia-loaned equipment has been returned.

Planned Activities for Next Quarter

- The DSJVP and USJVP contracts will be closed out.
- The remaining Sandia equipment in Cummins' possession will be returned.
- Cummins will provide a copy to Sandia of all documentation developed during the joint venture programs.

SAIC/STM USJVP

Status

The objective of the USJVP is to develop 25-kW dish/Stirling systems for use in utility markets. The Energy Projects Division of SAIC in Golden, Colorado, leads a team comprising Stirling Thermal Motors (STM) of Ann Arbor, Michigan, and several utility partners. SAIC is the systems integrator and is also responsible for developing the solar concentrator and the second-generation faceted stretched-membrane dish. STM is developing the third generation of its kinematic Stirling engine for the project.

Accomplishments

- SAIC did not establish the source of its remaining Phase 2 cost share and Sun♦Lab funds were not provided after April 30. SAIC chose not to continue development and the project has been on hold.
- Because of the status of the project, no decision was made on the heat-pipe receiver, facet production tooling was not completed, the concentrator design was not completed, and laboratory testing of the first Phase 2 power conversion system at STM was not started.

Planned Activities for Next Quarter

- We are currently negotiating the re-start of the USJVP project with SAIC and are hopeful that we will be able to do so early next quarter.

Issues

- SAIC needs to define the commitment of $1.7 million of required Phase 2 cost share before we can approve the resumption of Phase 2 activities. We expect this issue to be resolved during the first quarter of FY97.

Major Milestones

Milestone	Planned	Actual
Deliver Cummins 7-kW_e system to Texas Utilities test site. *Concentrator delivered Nov 94.*	Mar 94 *Delayed until Dec 95.*	Nov 95
Deliver Cummins 7-kW_e system to Central and South West Services test site. *Concentrator delivered Nov 94.*	Apr 95 *Delayed.*	Canceled
Initiate backup NREC Brayton engine test cell testing at Cummins.	Apr 95 *Delayed.*	Canceled
Assemble first Cummins prototype 25-kW_e Stirling engine.	Sep 95 *Delayed.*	Canceled
Initiate laboratory testing of STM Generation III Stirling engine system. (SAIC)	Oct 95	Oct 95
Initiate testing of Aisin-Seiki 25-kW_e Stirling engine.	Nov 95	Dec 95
Start Phase 2 of SAIC USJVP.	Jan 96	Jan 96
Deliver Cummins 7-kW_e system to Cal Poly test site. *Concentrator delivered Dec 93.*	Feb 96 *Delayed.*	Canceled
Initiate testing of Cummins USJVP system.	Feb 96	Feb 96
Complete Phase 1 of Cummins USJVP; start Phase 2.	Apr 96	Mar 96
"Freeze" concentrator design. (SAIC)	Apr 96 *Delayed.*	
Make decision on heat-pipe receiver. (SAIC)	May 96 *Delayed.*	
Initiate testing of Cummins 7-kW_e water pump system.	Jun 96	Canceled
Test hybrid receiver on-sun. (SAIC)	Jul 96 *Delayed.*	
Down-select engine for the Cummins USJVP.	Sep 96	Canceled
Install first system at Mojave. (SAIC)	Sep 96 *Delayed.*	

Resources ($k)

	Sandia	NREL	DOE	Total
FTE Costs	277	100	0	**377**
Contracts	5,398	0	0	**5,398**
Total	**5,675**	**100**	**0**	**5,775**

C. MANUFACTURING AND TECHNICAL SUPPORT

The overall objective of the Manufacturing and Technical Support (MATS) task is threefold: (1) to provide timely and responsive technical support for users of solar thermal electric (STE) technology including domestic and selected international applications; (2) to apply Sun♦Lab's manufacturing expertise to assist solar thermal electric manufacturers in reducing the cost of their products; and (3) to initiate new activities and efforts as required by the program.

This task was initiated this year in response to program needs. In the past five years, the STE program has been engaged in a number of joint venture activities with industry that are producing new STE products. As these products are entering the prototyping and fielding phase of development, industry needs have shifted toward improving products' economic and field performance as well as reliability.

The national labs have a great deal of manufacturing and reliability improvement expertise that was developed in the defense programs. This MATS activity allows these capabilities to be applied on a timely and relevant basis. Manufacturer- and user-directed technical support will be provided on a case-by-case basis to users and manufacturers of STE technology. The MATS activity will allow the program to be continually flexible in supporting the constantly changing needs of the STE community. In addition, the MATS task will help initiate new activities as required by the STE program.

Status

During the quarter, the MATS team worked with Daggett Leasing Corporation of Daggett, California, to help identify the cause of the oil coking problem that is fouling the heat exchanger and reducing plant performance. In a closely related effort, an analysis is underway to identify the optimal cleaning period for the heat exchanger until a permanent solution to the oil coking can be found. Additionally, work was initiated to provide training to the Daggett Leasing operators on how to align their collectors. In another effort, the MATS team began work on site at Energy Laboratories, Inc.'s (ELI's) manufacturing facility to integrate the new absorber coating into its manufacturing process. Finally, the solar thermal electric presentations in Mexico were completed.

Accomplishments

- The MATS team began work to help Daggett Leasing develop a solution to the oil coking problem at the SEGS plant. The coking within the oil causes the heat exchanger to foul and degrades the plant performance. During the quarter, a contract was awarded to develop a technique to easily measure the amount of coking in the oil. This technique, which can be applied in the field, can help identify possible causes of the problem. There is also discussion about conducting a laboratory experiment to quantify more precisely the chemical process that causes the coking. The main objective of the effort is to eliminate the cause of the problem and then to clean the existing oil. This effort could potentially save millions of dollars for Daggett over the next few years.

- MATS engineers have initiated an effort to analyze steam train data relative to the heat exchanger at Daggett Leasing's SEGS plant. The issue is that the oil coking is causing the heat exchanger to foul and the objective is to determine the optimal interval for cleaning the exchanger. This analysis should provide the necessary information to answer this question.

- Sun♦Lab engineers have initiated a contractual effort with Kramer Junction Company (KJC) to train the operators at Daggett Leasing on field alignment techniques. The training is expected to begin next quarter and will allow Daggett to significantly improve the performance of its plant operations, especially in the SEGS II field.

- Sun♦Lab researchers have begun work on applying the new in-house coating methods developed at Sandia to the manufacturing process at ELI. The coating can be used for flat-plate or trough concentrator applications.

- Sun♦Lab engineers met with Harper Lake operators to identify needs for the plant. It was agreed that the modified SOLERGY model would be applicable to the plant's needs. As a result, both parties agreed that next quarter Sandia would prepare a version of the model for use on the SEGS VIII and IX systems. Later, Sun♦Lab engineers will help address the wind damage problem by applying a new prototype facet that was developed at Sandia.

- In support of technology applications in Mexico, Sun♦Lab staff organized the final set of STE technology presentations. The groups to which presentations were made include Mexican utility officials, state energy coordinators, universities and associated research institutions, and private concerns. The presentations were well received and resulted in a

verbal proposal to host a dish/Stirling demonstration project in Chihuahua, if an appropriate dish system can be made available.

Planned Activities for Next Quarter

- Sun♦Lab engineers will begin developing a modified SOLERGY code for the Harper Lake SEGS facility.
- Two efforts will be continued with Daggett Leasing: (1) the oil coking problem will be investigated and (2) work will continue with KJC on a training program for field alignment of the SEGS I and II fields.
- Under the CRADA, Sun♦Lab engineers will continue to refine the operation of the Sandia-developed selective coating process within ELI's manufacturing facility.
- Support to SAIC may be initiated to help improve the reliability of its dish/Stirling system.

Issues

- One of the milestones will be delayed until the first quarter of FY97. The milestone involves creating a modified SOLERGY code for the Harper Lake SEGS facility. The delay occurred because Harper Lake personnel indicated that their interest in the program has waned in recent months. However, they have now agreed that they would like to apply the program and it will be done next quarter.

Major Milestones

Milestone	Planned	Actual
Identify and initiate first manufacturing support activity.	Dec 95	Dec 95
Complete development of the Spanish version of the audio/ visual presentation on STE technologies.	Jan 96	Dec 95
Complete performance predictions for SEGS I and II based on recommended modifications.	Feb 96	Feb 96
Document support recommendations for all STE manufacturers.	Mar 96	Mar 96
Complete performance predictions for SEGS VIII and IX based on recommended modifications.	Apr 96 *Delayed.*	
Obtain a project proposal from key Mexican research institutions for a demonstration project.	Jun 96	Jun 96

Resources ($k)

	Sandia	NREL	DOE	Total
FTE Costs	163	0	0	**163**
Contracts	187	0	0	**187**
Total	**350**	**0**	**0**	**350**

D. SOLMAT

The objective of the solar manufacturing initiative is to develop manufacturing technology and processes that will permit cost-effective deployments of solar thermal systems in low-volume, early commercial applications; to reduce uncertainty in the cost and reliability of key solar components in order to improve financing of early commercial systems and reduce the risk of performance warranties; to promote the development of system-level business plans and industrial partnerships linking manufacturing scenarios to commercial sales prospects; and to establish the manufacturing basis for achieving the substantial cost reductions possible through higher volume production.

The Solar Thermal Manufacturing Technology (SolMaT) initiative is aimed at reducing the cost of solar thermal technologies in an environment of uncertain future sales and modest initial production volumes. In this way, SolMaT will fill a critical need for allowing solar thermal manufacturers to produce cost-effective products even before market demand will support high volume production.

Status

The SolMaT initiative presently has three contracted efforts in place. SAIC of Golden, Colorado, is in a validation phase of developing manufacturing technologies for heliostats. Rockwell International Corporation (Rockwell), of Canoga Park, California, is in a validation phase of developing improved manufacturing methods for central receivers. McDonnell Douglas Aerospace (MDA) of Huntsville, Alabama, is investigating alternate structural materials and manufacturing methods for dish/engine systems.

Accomplishments

- SAIC started Phase 2 of its SolMaT Heliostat Manufacturing Project. In this phase, four heliostats will be fabricated and installed according to methods developed in SAIC's Phase 1 effort. The objective is to validate the findings of the Phase 1 work with respect to expected manufacturing cost reductions and heliostat performance. During the quarter, SAIC completed a detailed tooling design for the membrane and mirror handling equipment. The former is in fabrication. SAIC's Golden facilities have been rearranged to allow the facet production line to be set up. A design of the membrane-to-ring automated welding equipment has been completed, and fabrication will begin soon. After reviewing quotes from four organizations, SAIC has selected Rockwell as the supplier of the heliostat structural components. SAIC tested single-membrane facets to determine focusing degradation caused by wind effect. CIRCE modeling showed that some degradation was apparent. Although SAIC felt the degradation was acceptable, it plans to increase the membrane tension to further reduce membrane wind deflection.

- We decided not to proceed with Phase 2 of the Solar Kinetics, Inc. (SKI) SolMaT work. This decision was based in part on the inability of SKI to meet its cost-share requirements for that work.

- A letter contract was initiated with Rockwell to start Phase 2 of the SolMaT contract. The letter contract allowed Rockwell to pursue procurement of long lead-time materials to be used to evaluate advanced manufacturing techniques for fabricating power tower receiver headers and nozzles. Rockwell was able to expedite delivery of critical long-lead-time items, taking months off the procurement time. Also during this quarter, we completed negotiations to finalize the terms and conditions of the Phase 2 SolMaT effort. The finalized contract will be signed in October.

- Members of the Sun♦Lab SolMaT team visited MDA in Huntsville on September 4, for a mid-term review of its dish concentrator manufacturing subcontract. MDA staff gave presentations on work done to date, a Phase 2 work plan, and the status of their work on the heliostats. Work is progressing on all three technical tasks. For Task 1, mirror facet fabrication, Bent Glass Designs of Kings of Prussia, Pennsylvania, has delivered two sagged glass panels to Silver Service of Chicago Heights, Illinois, for silvering. MDA will then finish these two facets with a lay-up backing structure and have them optically tested at its test site in Huntington Beach, California. If the facets prove optically acceptable, then the production of approximately 20 more facets will begin. Task 2 involves fabrication of the center facet support structure using fiberglass/epoxy composite materials. MDA is experimenting with several methods of composite lay-up aimed at reducing the amount of process time and labor. This task is closely coupled with Task 3, facet attachment. In Task 3, MDA will be producing two complete center structures with facets. One will incorporate MDA's standard three-point attachment scheme (allowing facet pointing adjustment) while the other will use a bonded attachment scheme (with no adjustment capability) aimed at reducing the number of parts and installation labor. Once complete, these two structures with facets will be tested for pointing accuracy at MDA's Huntington Beach facility.

Planned Activities for Next Quarter

- SAIC will continue to assemble tooling at its Golden facility. Rockwell will begin to fabricate tooling for the heliostat structural components. A single membrane facet will be fabricated to determine its structural stability and the facet will be subjected to wind testing to determine membrane deflection under wind loading.
- Rockwell will focus on project planning, layout of a final schedule, and holding a kickoff meeting at Sandia. Rockwell will also start the design activities for each of its five major tasks.
- MDA will wrap up Phase 1 of its contract. Initial facets and support structure will be fabricated and independent optical/structural qualification of these preliminary constructions will be performed. Optical testing of the integrated facet/support structure will follow. A second complete structure will then be fabricated based on results of the first construction. This unit will also be tested for optical performance. Environmental exposure testing of both facet and support structure materials will also be started within the next quarter. A final report will be delivered and an end-of-project review meeting held. The Phase 2 work plan will also be completed in preparation for Phase 2 work.

Major Milestones

Milestone	Planned	Actual
Sponsor DFMA workshop for heliostat developer.	Mar 96	Dec 95
Complete SAIC Phase 1 heliostat work.	Apr 96	Apr 96
Complete SKI Phase 1 heliostat work.	Apr 96	Apr 96
Complete Rockwell Phase 1 central receiver work.	Jul 96	Jul 96
Identify manufacturing technologies/methods for 20% cost reductions for near-term heliostat production.	Aug 96	Aug 96

Resources ($k)

	Sandia	NREL	DOE	Total
FTE Costs	48	104	0	**152**
Contracts	200	879	0	**1,079**
Total	**248**	**983**	**0**	**1,231**

E. SYSTEMS AND MARKETS ANALYSIS

The objective of the systems and markets analysis task is to develop an improved understanding of solar thermal electric technologies and their applications, to support the analysis of advanced technology concepts, to identify ways to reduce capital and operation and maintenance (O&M) costs and/or increase performance, and to identify the key issues affecting the commercialization of the technologies and market identification.

Status

During the quarter, an economic analysis of STE hybrid technologies was performed to evaluate the cost of using STE technologies to reduce CO_2 emissions, additional validations of the FATE2-P model and the California Energy Commission (CEC) tax equity analysis were performed, a contract was established to develop a new low emissivity heat-collector element (HCE), new mirror washing hardware was tested, and the SolarPlan study for India was initiated.

Accomplishments

- An analysis of the economics of hybrid and solar-only power towers was completed and documented in a conference paper to be presented at the 8th International Symposium in Cologne, Germany, in October 1996. Several hybrid and solar-only configurations were evaluated. In general, hybrid power towers were shown to be economically superior to solar-only plants with the same field size. Furthermore, the power-booster hybrid approach was generally preferred over the fuel-saver hybrid approach. Using today's power tower technology, economic viability for the solar power-boost occurs at fuel costs in the neighborhood of $2.60/MMBtu to $4.40/MMBtu (low heating value), depending on whether coal-based or gas-turbine-based technology is being offset. The cost of CO_2 avoidance was also calculated for solar cases in which the fossil fuel cost was too low for solar to be economically viable. The avoidance costs are competitive with other proposed methods of removing CO_2 from fossil-fired power plants.

- Richard Chapman, the consultant supporting the CEC's Tax Equalization studies, used the FATE2-P model to compare with the CEC's small circle tax equity analysis. A number of minor corrections were identified in the FATE2-P and CEC models. Generally good agreement was observed between the model results, thus providing additional validation of the original CEC work.

- We established a contract with SOLEL Solar Systems Limited to develop a new cermet coating for the HCEs within a parabolic trough plant. Initial results indicate the emissivity of the new coating is about 40% lower than previously available coatings. This advancement significantly reduces heat losses in the solar field and is expected to lower the levelized energy cost from trough plants by approximately 4%.

- As part of our project to reduce O&M costs at solar thermal power plants, KJC Operating Company tested a new mirror washing apparatus. A rotating head is used to spray high pressure water on the mirrors. Initial results suggest that this new technique cleans the mirrors with nearly the same effectiveness as if they were scrub washed.

- With Bechtel Corporation, we began a study to investigate the techno-economic feasibility of constructing a molten-salt power tower in Rajasthan, India. This represents the first phase of the SolarPlan study that has been under active negotiation for the last year.

- We provided input to DOE's Technical Characterization Program. This program compares the techno-economic status of various renewable and energy-saving technologies under development at DOE.

- The final version of the second Interim O&M Cost Reduction Report was completed and distributed to the solar thermal community.

Planned Activities for Next Quarter

- The O&M Cost Reduction Program will begin a task to develop a new glass mirror facet that is less susceptible to breakage.

- NREL Resource Assessment has generated monthly and annual cloud-cover maps for Africa, Asia, Australia, and South America. A report will be generated to distribute the cloud-cover maps. In addition to the maps, data is being collected to generate direct normal insolation (DNI) maps for India.

- The CEC was awarded a contract for in-kind support from NREL for its work on tax equalizing strategies that improve the price competitiveness of renewable technologies. This work is a continuation of the tax equity analysis, which has been supported by the Solar Thermal Electric Program. The award is part of

NREL's Sustainable Technology Energy Partnerships (STEP) program. This effort is expected to begin during the next quarter.

Major Milestones

Milestone	Planned	Actual
Develop simplified tax equity model and use to verify previous tax equity studies (revised).	Jun 96	Sep 96
Develop cloud-cover maps for all promising international locations (revised).	Aug 96	Jun 96

Resources ($k)

	Sandia	NREL	DOE	Total
FTE Costs	185	196	0	**381**
Contracts	45	0	0	**45**
Total	**230**	**196**	**0**	**426**

II. TECHNOLOGY DEVELOPMENT

Technology development projects support the commercialization activities by developing, in collaboration with the private sector and the international community, solar thermal plant components and subsystems that meet the cost, performance, and reliability standards needed by industry.

A. OPTICAL MATERIALS

Low-cost, high-performance, and durable optical materials (reflectors and absorbers) are necessary to achieve the cost and performance goals needed for commercializing various solar thermal concentrating technologies. The objective of the Optical Materials Task is to identify and develop advanced optical materials for solar-thermal applications that meet industry's commercialization needs. The Optical Materials Team conducts basic research and analysis to better understand the fundamental properties that influence optical material performance; performs testing, characterization, and evaluation of candidate materials; and collaborates with the solar and materials industries to develop and test optical materials of near- and long-term interest.

Status

During the fourth quarter of FY96, optical materials development activities focused on providing support to the solar industry through research and development and manufacturing assistance. Sandia signed a CRADA with ELI for developing a nickel-based absorber for high-temperature applications. NREL continued to support SAIC by extending a subcontract for developing an alumina hardcoat reflector and by supporting the accelerated testing of adhesives for use with thin-glass mirrors. An advanced deposition system is nearing completion. Unfortunately, the anticipated CRADA with Rockwell International that would have benefited from use of the equipment was canceled because of Rockwell's recent reorganization.

Accomplishments

- A CRADA was signed with ELI for developing a high-performance, nickel-based absorber to be used in ELI's new high-temperature collector. Sandia staff spent several weeks at ELI helping ELI staff set up the manufacturing line.
- At the request of SAIC, NREL staff initiated accelerated weathering tests of adhesives used to bond thin-glass mirrors to SAIC's stretched-membrane facets. These tests directly support SAIC's USJVP and SolMaT efforts.
- The outdoor exposure test site was moved from Abilene, Texas, to a solar park in Ft. Davis, Texas. The solar park is active in a number of renewable energy demonstration projects and should afford greater visibility to solar thermal technologies.
- The advanced deposition system, scheduled for installation last quarter, has been delayed until the second quarter of FY97. The system will allow researchers to provide better support to current subcontracted efforts for advanced reflector development and to investigate innovative concepts generated internally.

Planned Activities for Next Quarter

- We will install a new accelerated exposure chamber.
- We will provide surface characterization results of reflector substrate material to an interested film manufacturer and a solar system manufacturer.
- We will activate a new optical spectrometer instrument.

Major Milestones

Milestone	Planned	Actual
Initiate CRADA for mid-temperature selective absorber development.	Feb 96 *Delayed until May 96.*	Jul 96
Complete development of video-based reflectometer.	Feb 96	Mar 96
Document results of thin-glass survey.	Mar 96	Mar 96
Complete installation of advanced deposition system.	Jul 96 *Delayed until Feb 97.*	
Complete critical assessment and down-selection of materials.	Jul 96 *Delayed until Sep 96.*	Oct 96
Document review of high-temperature absorber materials.	Aug 96 *Delayed.*	

Resources ($k)

	Sandia	NREL	DOE	Total
FTE Costs	130	819	0	**949**
Contracts	0	211	0	**211**
Total	**130**	**1,030**	**0**	**1,160**

B. CONCENTRATOR TECHNOLOGY

The objective of concentrator technology development is to bring heliostat and parabolic dish concentrators to commercial readiness for use in solar thermal electric systems. Concentrator technology is structured to develop new, innovative ideas and conceptual designs for solar concentrators that will lead to more cost-effective and/or high performance heliostats and dishes. This task includes developing specialized instrumentation for optical measurement, optical materials, and concentrator evaluation techniques; providing industry support; and developing advanced concepts. As activities within this task become more developed and formalized, they generally "spin off" into their own projects within concentrator technology or another area of the Solar Thermal Electric Program.

Optical Tool Development

Status

The solar concentrator is the first component in the sequence of technologies that comprise a solar thermal electric power generation system. Because the concentrator provides the fuel for the system, it is important to know precisely how it performs. During this quarter we made advances on both the Video SHOT system and the beam characterization system (BCS) and prepared a presentation on the 2-*f* system.

Accomplishments

- The prototype Video SHOT system was completed and tested.
- We will not assist Cummins with setting up a Video SHOT system because Cummins has left the program and is no longer pursuing dish/Stirling development.
- The BCS components were assembled into a system at NREL and will be used to test the SAIC dish during Phase 2 of the USJVP project.

Planned Activities for Next Quarter

- Video SHOT will be qualified in evaluating foam facets, Cummins facets, and the Kansas Structural Components, Inc. (KSCI) and the Russian facets.

Industry Support

Status

As part of the concentrator technology task, we provided measurement and engineering in support of the dish/Stirling project and the Solar Two project to those requiring help designing or evaluating their concentrator design.

Accomplishments

- There was no activity this quarter.

Planned Activities for Next Quarter

- We will continue to provide support for dish/Stirling projects and Solar Two as needed.

Advanced Concepts

Status

Advanced concepts provide the "seeds" from which the next-generation technologies grow and mature. Under this task, we are focusing on a number of areas that have a major impact on the performance and cost of solar concentrators. We have contracts in place with KSCI to provide composite facets; with Edtek, Inc. to produce a blow-forming die and design an aluminum quenching subsystem; with SAIC to evaluate advanced drive concepts; and with SKI and AlliedSignal to complete a component conceptual design.

Accomplishments

- KSCI delivered a 3-m-diameter round facet for a faceted stretched-membrane dish to SAIC but it was damaged in shipping. KSCI will deliver a replacement.
- Edtek, Inc. was scheduled to fabricate a 48-in.-diameter prototype facet and complete the cost estimates for facets formed using its process. Because of cost overruns on its project, Edtek will not be able to build the 48-in. facet. The cost estimates for its project will be provided in its final report next quarter.
- We conducted the final design review for the SKI/AlliedSignal Dish Brayton Project and determined to examine in more detail the design of a thermal receiver for the system. Therefore, we extended the contract through November.
- The Final Design Report for the SKI/AlliedSignal Dish Brayton Project will be provided during the second quarter of FY97.

- A low-cost glass/glass lamination was fabricated. Preliminary evaluations indicate significant "spring back."
- A laboratory scale process for fabricating prototype foam-in-place urethane foam facets was developed. Several prototypes were fabricated for evaluation.

Planned Activities for Next Quarter

- We will hold an Advanced Concentrator Workshop where the KSCI, Edtek, and SAIC projects, as well as the internal Sun♦Lab projects, can be presented to industry.
- We will complete the AlliedSignal project.
- We will complete the final reports and close outs of the three Advanced Concentrator projects.
- We will fabricate additional urethane foam facets for evaluation.
- We will complete the Video SHOT evaluation of prototype foam facets and initiate environmental testing.

Major Milestones

Milestone	Planned	Actual
Complete support of USJVP dish test at Cummins.	Oct 95	Oct 95
Place advanced concentrator contracts.	Nov 95	Nov 95
Complete heliostat field upgrade support.	Nov 95	Nov 95
Review Video SHOT system design.	Dec 95	Dec 95
Test prototype TBC foam facets.	Mar 96	Mar 96
Complete Video SHOT prototype system.	May 96 *Delayed.*	Sep 96
Complete SKI/AlliedSignal project.	Jul 96 *Extended.*	
Test heliostat-type foam facets.	Sep 96	Canceled

Resources ($k)

	Sandia	NREL	DOE	Total
FTE Costs	850	104	0	**954**
Contracts	130	128	0	**258**
Total	**980**	**232**	**0**	**1,212**

C. POWER TOWER TECHNOLOGY

The purpose of the Power Tower Technology Development Project is to advance the development and commercialization of central receiver technologies by mitigating the risks of central receiver systems through research and development activities. We also support industry and utility concerns by conducting research on new concepts and by performing tests and analyses of components and procedures. The rationale for these activities is that there are significant demands for new generating capacity in foreign markets (estimated to be over 500 GW_e by 2002); these demands can partly be met by solar thermal central receiver technology. In addition there are significant commercial domestic renewable energy projects proposed (that is, National Solar Enterprise Zone, Sacramento Municipal Utility District (SMUD), plus possibly other small power tower projects). Support for research, development, and testing of advanced receivers, concepts, materials, and components is critical for reducing the risks and implementing enhancements in reliability and economics into the first commercial plants. The Sun♦Lab participants will provide the technical expertise to industry for producing the first commercialization plants.

Status

This fiscal year, the main tasks in power tower technology have been the following: (1) support the Solar Two project on technical issues and with the test and evaluation phase; (2) continue developing an advanced receiver through the Rockwell CRADA; (3) refurbish the National Solar Thermal Test Facility (NSTTF) to support future receiver tests and facility projects; (4) conduct central receiver development tasks, which include impedance heating tests and molten-salt cold pipe tests; (5) conduct a study with SMUD on combined cycle power towers; and (6) develop advanced concepts in central receivers (including testing of the International Energy Agency/Task III internal film receiver project at Plataforma Solar de Almeria, assessing (by modeling) potential low emissivity coatings, and completing experiments to measure corrosion rates of potential steam generator materials in nitrate salt).

Accomplishments

- Sun♦Lab supported the Solar Two project by providing consultation and support during the refurbishment of heat trace at Solar Two. In addition, a corrosion survey of the field was conducted and preparations for the 20-day baseline test continued.

- The second year of the Rockwell CRADA to develop an advanced central receiver has begun. The second project year was significantly scaled back because of limited funding by Rockwell. Sandia will complete fatigue testing of advanced materials. The original date to complete the milestone for the thermomechanical fatigue tests could not be met because the material took longer than expected to fail. Activities in the Rockwell SolMaT project will be leveraged with the CRADA to make use of limited funding.

- The tower elevation module has been refurbished this quarter. The tower module is the large platform in the center of the NSTTF tower where test articles are built and elevated to the top. Refurbishment of this module will allow us to test large articles at the NSTTF, including a Rockwell panel.

- The heliostat field can reliably track 140 heliostats. We expect 25 to 30 additional heliostats to work, but less reliably than the other recently repaired heliostats.

Planned Activities for Next Quarter

- We will continue to provide support to the Solar Two project.

- We will begin modifications to the salt flow loop, including removing existing panels and support structures and assessing the condition of and repairing the cooler.

- We will define interface requirements with Rockwell for the few-tube test panel.

- We will conduct second-year fatigue tests for the Rockwell CRADA.

Major Milestones

Milestone	Planned	Actual
Complete testing of the 500-kW_t Recepto Avandazo de Sales internal molten-salt film receiver at Plataforma Solar de Almeria.	Sep 95	Canceled
Complete corrosion testing of advanced steam generator materials for molten-salt applications.	Dec 95	Dec 95
Complete planned impedance heating tests.	Feb 96	Mar 96
Complete thermomechanical fatigue tests for Rockwell CRADA panel design.	May 96 *Delayed.*	
Complete molten-salt cold-pipe fill tests.	Jun 96	Feb 96
Complete process control upgrade for Rockwell panel test.	Jul 96 *Delayed until Mar 97.*	
Complete facility preparations for Rockwell panel test.	Sep 96	Sep 96

Resources ($k)

	Sandia	NREL	DOE	Total
FTE Costs	685	120	0	**805**
Contracts	445	0	0	**445**
Total	**1,130**	**120**	**0**	**1,250**

D. DISH CONVERSION TECHNOLOGY

In cooperation with industry, Sun♦Lab has been engaged in a program to solarize, test, and evaluate power conversion systems that have the potential to be utilized in commercial solar-thermal electric point-focus systems. The goals of this program are to engage in projects that directly support ongoing commercialization efforts; to develop solar-thermal power-conversion systems that are candidates for commercialization; to pursue advanced development of solar-specific components; to identify and respond to solar-specific design issues; and to increase the general industry knowledge base on system integration and testing techniques. Support efforts have concentrated on Stirling engine performance improvements, Brayton system proof-of-concept, reflux receiver development and testing, and hybrid receiver development and support.

Status

We completed fabrication and test preparations for the integrated test of a Thermacore heat-pipe receiver and the STM 4-120 Stirling engine. We have made significant progress toward a viable hybrid heat-pipe receiver, including burner tests correlated with thermal and flow models and manufacturing samples of heat transfer surfaces. We continued investigating the cause of the hot spots we observed on several full-scale felt-wick receivers. We have contracted with a Russian laboratory with significant heat pipe experience to further our understanding of corrosion. We continue to directly support our commercial partners through design, analysis, and test support for both engines and receivers.

Accomplishments

- We completed interfacing the Thermacore sintered-powder receiver to the STM engine, and completed the bakeout and sodium-fill operation.
- A preliminary run was performed on one of the felt-wick heat-pipe capsules that will be used in long-term materials and cleaning tests. Four of the capsules have been constructed and filled, and testing will begin immediately after the safety documentation is approved.
- We completed our assessment of the metal matrix burner operating in the radiant mode. Analysis of the data indicate that the matrix is likely to operate at excessive temperature for the hybrid receiver application.
- We initiated an assessment of the metal matrix burner operating in the blue-flame mode. Test results show that this mode allows the matrix to operate at a much lower temperature and at the same time produces a stable flame that should be well suited for the hybrid receiver application. We used the results of these tests to calibrate our heat-transfer model.
- We completed a computational fluid dynamics assessment of the pin-fin convection section for the hybrid receiver with a blue-flame metal matrix burner. The results are encouraging and suggest a design for a prototype gas-fired heat pipe to be tested for validation purposes in FY97.
- Sandia metallurgists have analyzed hybrid-receiver pin-fin heat-exchanger fabrication samples and made recommendations for improvements. Discussion of these results with the vendors is underway.
- The Sun♦Lab Dish Technology Team took a three-day course, "Planning Innovative Projects," during which the team was able to plan an FY97 project. We completed a detailed project plan to design, fabricate, and test a prototype gas-fired heat pipe in FY97. This test will be used to validate results of lab testing and computational fluid dynamics calculations and lead to the design of a full-scale hybrid heat-pipe receiver.
- Samples from a durability felt-wick heat pipe that ran for 1300 hours have been sectioned and analyzed with a scanning electron microscope (SEM). A deposit of what appeared to be copper was found beneath the surface of the wick in the vicinity of the hot spot that ended the test. Evidence of dissolution was found on both evaporator and condenser fibers, with the evaporator showing slightly more attack. In contrast to the previous durability heat-pipe, extensive deposits were not found in the evaporator region.
- We sectioned samples from the third generation felt-wick receiver that were analyzed at Sandia-Livermore. The wick structure had separated from the Haynes 230 substrate and left a 200-micron gap in the vicinity of one of the hot spots on the absorber surface. The SEM provided evidence of dissolution of the stainless steel fibers in some areas.
- The Sun♦Lab Dish Technology Team has placed a contract with Dr. Alexander Shimkevich, Institute for Physics and Power Engineering (IPPE), Obninsk, Russia, for technical information to improve the lifetime and performance of felt/metal wicks.
- We are discussing additional collaborations on felt wick technology, most likely funded by proliferation prevention programs, with Dr. Shimkevich and with Dr. Vladimir Baturkin, Kiev Polytechnic Institute, Kiev, Ukraine.

- We have continued interface plans for testing the NREC Brayton engine on the test bed concentrator (TBC). However, at this point, the contract for the engine development is on hold.
- Sandians Steve Goods and Bob Bradshaw continue to analyze the Stirling Technology Company (STC) NaK capsule tests.
- Mona Fowler received her Master's degree in August from North Carolina Agricultural and Technical State University (NCA&T), after collaborating with Sandians Jim Moreno and Phil Heerman on the use of artificial neural networks to model reflux receiver performance, under the auspices of the DOE Science and Technology Alliance.
- We continue to work with Mary Murdock (a Ph.D. student in Mechanical Engineering at NCA&T), and her adviser, Professor Tony Min, to formulate a dissertation topic on reflux receiver transient thermal stress.
- We encouraged STM and Thermacore to begin a business relationship to study the applicability of Thermacore's heat pipe technology to the STM solar package on the SAIC dish.
- We visited AlliedSignal to gather information about the current state of Brayton technology in sizes appropriate for dish/electric systems. A small (30- to 60-kW_e) engine is under development and is expected to be marketed in three years.

Planned Activities for Next Quarter

- We will complete performance mapping of the STM/Thermacore package on Sandia's TBC in order to compare system performance to the directly illuminated receiver package tested earlier. The resulting data will be immediately shared with STM, Thermacore, and SAIC for application to the remaining Joint Venture Program.
- We will begin long-term testing of the cleaning-procedures heat-pipe test capsules after safety documentation is completed.
- We will continue test and analysis support of the Joint Venture Program engine and receiver tasks.
- We will complete our investigation of full-scale felt-wick heat-pipe hot spots and design a new version of the receiver to address any issues discovered.
- We will substantially complete design of a bench-scale gas-fired hybrid heat-pipe receiver.
- We will fabricate a prototype hybrid receiver heat exchanger to evaluate manufacturing issues.
- We will review a report from the IPPE on heat-pipe felt-wick technology.
- We will submit a proposal to the Initiatives for Proliferation Prevention Program for collaborations with the IPPE and the Kiev Polytechnic Institute.
- We will complete metallurgical analysis of the STC NaK capsule tests.
- We will continue collaborations with NCA&T, and we will review proposed dissertation research, to be performed for Sun♦Lab by a Ph.D. candidate at NCA&T, under the auspices of the DOE Science and Technology Alliance.

Issues

- NREC requires more funding to overcome difficulties experienced with compressor-stage failure.

Major Milestones

Milestone	Planned	Actual
Complete integrated testing of STM engine with a heat-pipe receiver.	Feb 96	Mar 96
Begin materials compatibility capsule tests.	Feb 96	Mar 96
Complete testing of third-generation heat-pipe receiver.	Mar 96 *Delayed until May 96.*	May 96
Complete testing of NREC Brayton system.	May 96 *Delayed indefinitely.*	

Resources ($k)

	Sandia	NREL	DOE	Total
FTE Costs	1,267	118	0	**1,385**
Contracts	820	150	0	**970**
Total	**2,087**	**268**	**0**	**2,355**

E. FACILITIES SUPPORT

The DOE's National Solar Thermal Test Facility (NSTTF) is the primary test facility for testing solar thermal components and systems in the United States. The facility is also a DOE Designated User test facility. Originally constructed as the Central Receiver Test Facility in the late 1970s, the mission of the facility has been expanded to include distributed solar thermal technologies, solar furnace testing, and engine testing for solar technologies. In addition, the unique capabilities of the NSTTF are often applied to a wide variety of tests unrelated to solar energy that require high temperature, high flux, and excellent data acquisition capabilities. The facility support activity covers the basic operation and maintenance of the NSTTF.

Status

The NSTTF continues to support all the technology development programs and many of the commercial applications projects. All facility support for those programs and projects is covered in other parts of this report. In addition to the T&E support, the NSTTF staff continues to maintain an excellent record in addressing environment, safety, and health (ES&H) requirements. A significant effort during this year is to remove old and unneeded systems and test fixtures. We are also pursuing other nonrenewable T&E business opportunities to leverage the operation and maintenance costs of the facility.

Accomplishments

- We continued refurbishment of the NSTTF field to prepare it for the User Facility activities, the Work for Others activities, and the Rockwell panel test. This quarter we maintained the field at 150 available heliostats, procured new motors, and initiated a contract to purchase new encoders.
- An operating procedure for the tower module has been prepared to test operate the module next quarter.
- We continued to work on the Applied Physics Laboratory Work for Others project. We continued to prepare the heliostat field and 260-ft. test bay for conducting boresite measurements on a new radome.
- We conducted two sets of astrophysics experiments tests for the University of Chicago at NSTTF under a User Facility Agreement. The University of Chicago and other universities used the NSTTF field as a large antenna to conduct their experiments looking for Cherenkov radiation. Work was completed in October.
- We were successful in getting DOE to close out the contract on the "old" Power Kinetics Inc. (PKI) dish. The dish was destroyed in the wind storm of August 1994 and it is a safety hazard. We have been working with DOE to close out the contract since the storm.

Planned Activities for Next Quarter

- We will continue to repair and modify the heliostat field in support of the Applied Physics Laboratory and the Rockwell panel test.
- We will continue the fabrication, installation, and testing for the Work for Others contract with Applied Physics Laboratory. Testing will be initiated in November 1996.
- We will continue to remove obsolete equipment and tests.
- We will initiate removal of the PKI dish.

Major Milestones

Programmatic milestones for testing technology are addressed in each of the technology sections.

Resources ($k)

A majority of the NSTTF's activities, including maintenance and upgrade, are funded proportionately by all users, the majority of which are associated with the Solar Thermal Electric Program. However, the funds shown below apply to the core operation of the facility.

	Sandia	NREL	DOE	Total
FTE Costs	100	0	0	**100**
Contracts	100	0	0	**100**
Total	**200**	**0**	**0**	**200**

F. COMMUNICATIONS

The objective of the Sun♦Lab Communications Team is to create effective communications products for the DOE's Solar Thermal Electric Program. These products and related exhibit materials explain the results of work performed by Sun♦Lab and make results of research available to the constituents of the program.

Status

During the fourth quarter of FY96, the Sun♦Lab Communications Team took part in the planning for FY97, while continuing ongoing work on the Solar Two video, placement of an article about Solar Two in a national magazine, and development of the Internet pages.

Accomplishments

- Jim Jones (NREL) and Anne Van Arsdall (Sandia) contacted leaders of Sun♦Lab projects among staff members from Sun♦Lab, DOE sponsors, and industry partners to identify communications needs for FY97.

Planned Activities for Next Quarter

- The Communications Team will provide services and products to the Sun♦Lab Solar Thermal Electric Program as needed.
- Jones, Van Arsdall, Joe Flores (SCE), and Rick Clyne (an NREL contractor) will write a script for the video about Solar Two, with filming to follow.
- Jones will continue to identify and target publications in which to place a major article about Solar Two.

Major Milestones

Milestone	Planned	Actual
Complete Solar Two brochure (carryover from FY95 under the Technical Information Program).	Mar 96	Mar 96
Produce brochure and Soltech '96 exhibit for Sun♦Lab.	Mar 96	Mar 96
Provide support, including an informational video, for the Solar Two inauguration and visitor center.	Jun 96	Jun 96
Establish draft Sun♦Lab home pages on the Internet.	Jun 96	Jun 96
Create a brochure on dish/Stirling for the 1996 Summer Olympic Games.	Jul 96	Jun 96
Place an article about Solar Two in a national magazine.	Sep 96 *Delayed.*	
Place an in-flight Solar Two video on an airline video program.	Sep 96 *Delayed.*	
Update the Sun♦Lab home pages on the Internet	Sept 96	Sept 96

Resources ($k)

	Sandia	NREL	DOE	Total
FTE Costs	25	60	0	**85**
Contracts	15	0	0	**15**
Total	**40**	**60**	**0**	**100**

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Meetings and Presentations

Adkins, D.R., C.E. Andraka, R.W. Bradshaw, S.H. Goods, J.B. Moreno, and T.A. Moss, ***Mass Transport, Corrosion, Plugging, and Their Reduction in Solar Dish/Stirling Heat Pipe Receiver,*** presented atf the Intersociety Energy Conversion Engineering Conference, August 1996, Washington, D.C.

Andraka, C.E., K.S. Rawlinson, T.A. Moss, D.R. Adkins, J.B. Moreno, D.R. Gallup, and P.G. Cordeiro, ***Solar Heat-Pipe Testing of the Stirling Thermal Motors 4-120 Stirling Engine,*** Proceedings of the Intersociety Energy Conversion Engineering Conference, August 1996, Washington, D.C.

Bohn, M.S., ***Application of Radiant Burner Technology to Hybrid Dish/Stirling Systems,*** submitted for presentation at the 1997 ASME International Solar Energy Division Conference, April 1997, Washington, D.C.

Fowler, M., D. Klett, J.B. Moreno, and P.D. Heerman, ***Using Artificial Neural Networks to Predict the Performance of a Liquid Metal Reflux Solar Receiver: Preliminary Results,*** SAND95-2789C, presented at the Fourth Annual Historically Black Colleges and Universities/Private Sector—Energy Research and Development Technology Transfer Symposium, April 1996, Greensboro, North Carolina.

Fowler, M., D. Klett, J.B. Moreno, and P. Heerman, ***Using Artificial Neural Networks to Predict the Performance of a Liquid Sodium Reflux Pool Boiler Solar Receiver,*** to be presented at the 1997 ASME International Solar Energy Division Conference, April 1997, Washington, D.C.

Grossman, J.W., and R.M. Edgar, ***Transforming the Sandia 2-f Optical Performance Measurement System to Color,*** SAND96-0204C, presented at the American Society of Mechanical Engineers International Solar Energy Conference, March 31-April 3, 1996, San Antonio, Texas.

Jones, S.A, ***Annual Performance Predications for Off-Axis-Aligned LUGO Heliostats at Solar Two,*** presented at the American Society of Mechanical Engineers International Solar Energy Conference, March 31-April 3, 1996, San Antonio, Texas.

Jones, S.A, ***A Comparison of On-Axis and Off-Axis Heliostat Alignment Strategies,*** Solar 96, presented at the 1996 Annual Conference of the American Solar Energy Society, April 1996, Asheville, North Carolina.

Pacheco, J.E., and S.R. Duncan, ***Assessment of Molten-Salt Solar Central-Receiver Freeze-up and Recovery Events,*** presented at the American Society of Mechanical Engineers International Solar Energy Conference, March 31-April 3, 1996, San Antonio, Texas.

Pacheco, J.E., and W.J. Kolb, ***Testing of An Impedance Heating System for Solar Power Tower Applications,*** presented at the 1996 AIChE National Heat Transfer Conference, August 3-5, 1996, Houston, Texas.

Prairie, M.R., J.E. Pacheco, and G.J. Kolb, ***Solar Central Receiver Technology: The Solar Two Project,*** presented at the 1996 AIChE National Heat Transfer Conference, August 3-5, 1996, Houston, Texas.

Price, H., D. Whitney, H. Beebe, ***SMUD Kokhala Power Tower Study,*** presented at the American Society of Mechanical Engineers International Solar Energy Conference, March 31-April 3, 1996, San Antonio, Texas.

Price, H., ***Integration of Solar Thermal Electric Technologies with Gas Turbine Systems,*** presented at the Electric Power Research Institute Gas Turbine Workshop, March 27-28, 1996, Denver, Colorado.

Price, H., ***Solar Thermal Hybrids: The Next Step,*** presented at the SOLTECH/UPVG 1996 Annual Meeting, March 13, 1996, Palm Springs, California.

Stine, W.B., ***Solar Electric Applications of Stirling Engines,*** presented at the 7th International Conference on Stirling Machines, November 1995, Tokyo, Japan.

Strachan, J.W., R.B. Diver, and C. Estrada, ***Dish/Stirling Systems: Overview of an Emerging Commercial Solar Thermal Electric Technology,*** presented at the 1995 Annual Meeting of the Mexican Solar Energy Association, October 1995.

Tyner, C.E., J.P. Sutherland, and W.R. Gould, Jr., ***Solar Two: A Molten Salt Power Tower Demonstration*** in VDI Berichte 1200, Verein Deutscher Ingenieure: SolarThermische Kraftwerke II Tagung Stuttgart, 11 und 12 Oktober 1995. ISBN 3-18-091200-6.

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