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Annual Operating Plan
Fiscal Year 1998

October 1997

U. S. Department of Energy
Solar Thermal Electric Program

SOLAR•THERMAL•ENERGY
Sun•Lab
Sandia National Laboratories, Albuquerque, NM
National Renewable Energy Laboratory, Golden, CO

Operated for the United States Department of Energy

FOREWORD

The FY98 budget allocated by Congress for the Solar Thermal Electric Program is $16.8 million, down significantly from the requested $19.5 million. Although there was some indication from Congress that a supplemental allocation might be provided later in the year, this Annual Operating Plan is based on $16.8 million, with several additional items identified for funding only if supplemental funds are provided. Budget reductions were made in a manner to provide continuity in all critical programs, but also to ensure minimization of uncosted balances at year-end.

In spite of budget reductions, we expect major progress this year as Solar Two initiates test and evaluation operations in parallel with full power production; Science Applications International Corporation (SAIC) installs and begins testing five USJVP Phase 2 dish/Stirling systems; AlliedSignal and Boeing North American begin dish/engine critical component development; major test and evaluation programs are initiated for the advanced Boeing central receiver panel and the SAIC SolMaT heliostat; and development efforts in materials, concentrators, dish conversion, and systems analysis continue. In addition, as a result of advances in the technology and the evolving power market, we have initiated several new activities, including investigation of advanced parabolic trough systems and an assessment of market opportunities and potential project developers.

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INTRODUCTION

Solar thermal electric (STE) technologies — parabolic troughs, power towers, and dish/engine systems — convert sunlight into electricity efficiently and with minimum effect on the environment. These technologies generate high temperatures by using mirrors to concentrate the sun's energy up to 5000 times its normal intensity. This heat is then used to generate electricity for a variety of market applications, ranging from remote power needs as small as a few kilowatts up to grid-connected applications of 200 MW or more. STE can begin providing energy, as well as economic and environmental security, for us today. In the long term, these technologies will compete broadly in U.S. and international markets for electric power production.

Solar thermal electricity is the least costly solar electricity for grid-connected applications available today, and it has the potential for further, significant cost reductions. While not currently competitive for utility applications in the United States, the cost of electricity from STE can be competitive in international and domestic niche applications, where the price of energy is higher. Our goal for advanced STE technologies is costs below 5¢/kWh. At these costs, our vision for the future, 20 GW of installed STE capacity by the year 2020, is achievable.

OUR VISION

Our vision for success of the Solar Thermal Electric Program is world leadership by U.S. industry in supplying 20 GW of solar thermal electric power by 2020.

OUR MISSION

Our mission within the Department of Energy's (DOE's) Solar Thermal Electric Program is to help provide for the energy, economic, and environmental security of the United States. We will fulfill our mission through research, development, demonstration, technical support, and economic and policy analyses to help U.S. industry deploy solar thermal technologies in global, renewable energy markets.

OUR OBJECTIVES

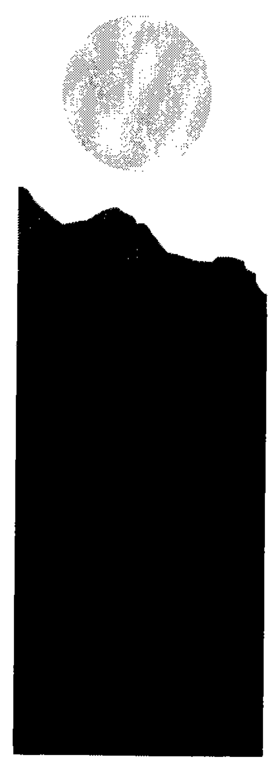
Our objectives for the Solar Thermal Electric Program are to

- Help industry bring STE technologies to near-term markets; and
- Provide the technical advances needed by industry for expansion into future markets.

OUR STRATEGIES

Our strategies for achieving these objectives, listed in descending order of importance, are to

- Support the next commercial opportunities for STE technologies;
- Demonstrate improved performance and reliability of STE components and systems;
- Reduce STE energy costs;
- Develop advanced STE systems and applications; and
- Address nontechnical barriers and champion STE power.



conditions. A validated panel will provide confidence to Boeing to submit a proposal for a commercial power tower bid.

SAIC Heliostat Testing

We will characterize optical performance, tracking, and control of SAIC's 170 m^2 SolMaT heliostat at the National Solar Thermal Test Facility (NSTTF). We will document performance of one of the potential heliostats for the first commercial power tower plants.

Evaluate Improved Molten Salt Components

In this task, we will evaluate a long-shafted hot pump with salt-cooled bearings for molten-salt power towers. Implementing a long-shafted pump will greatly simplify the molten-salt system by eliminating the pump sumps and several valves, leading to improved reliability and lower assembly costs for power towers.

Materials Characterization

We will characterize receiver and piping materials for off-normal events and stress corrosion cracking. It is critical that we understand the phenomenon that led to the stress corrosion cracking of the Solar Two receiver and piping and know the actual behavior of these materials.

Hybrid Molten-Salt Components

Hybrid power towers offer a number of advantages over solar-only systems for early commercial deployment of the technology. These advantages include enhanced modularity, lower financial risks, reduced technical risks, and lower energy costs. With the changes in the domestic and world markets for bulk power, hybrid power towers are likely to have the best opportunities for early power projects. The objectives of this activity are to identify and define alternative power tower concepts that can meet a variety of market conditions and to identify development paths. Although the focus will be primarily on options for hybridizing molten-salt power towers, we will also briefly review other alternatives. The activities will be closely coordinated with the technology roadmapping activity for power towers that will be conducted in the systems analysis task.

Evaluate Hybrid Power Tower Concepts

The objective of this activity is to complete a screening analysis of advanced power tower concepts (e.g., alternative thermodynamic cycles and system designs) for various bulk-power market applications. We will begin by developing a set of ranking criteria (such as levelized energy cost, solar investment costs, solar fraction, etc.) that can be used to objectively evaluate and compare alternative approaches. We will develop a list of alternative hybrid approaches, starting with the recently completed SolarPACES catalog of hybrid designs, and supplement it with literature reviews and results of internal brainstorming sessions. We'll then evaluate each of these systems against the ranking criteria and develop ranking of the concepts for alternative markets and deployment timetables. We will complete the study before the power tower road-mapping meeting and present the results to that group for discussion and debate.

Identify Salt-Specific Hybrid Hardware

At the power tower roadmapping meeting, we expect to recommend one or two paths to pursue for hybrid power tower development. Based on the recommendations, we will identify specific components that need to be designed and tested before beginning a commercial project. We will then develop a prioritized, time-phased schedule and budget for completing these tests within the next three to five years.

Major Milestones – Power Tower Activities		
Milestone Description	**Staff Responsible**	**Expected Completion**
Complete the 100-hour Solar Two plant acceptance test.	M. Prairie	Dec 97
Document results of the Solar Two Test and Evaluation Program for 1997.	M. Prairie	Jan 98
Enter the Power Production Phase of Solar Two.	H. Reilly	Jan 98
Complete and document the Solar Two steam generation system characterization test.	J. Pacheco	Apr 98
Complete testing of the Boeing panel.	J. Pacheco	May 98
Complete and document the Solar Two receiver efficiency test.	J. Pacheco	Jun 98
Present results of the hybrid study at the Roadmapping Workshop.	T. Williams	Jun 98
Demonstrate dispatchability: generate electricity with Solar Two for three hours after dark at maximum power output.	H. Reilly	Jul 98
Complete characterization of SAIC's heliostat at the NSTTF.	J. Grossman	Sep 98
Document Solar Two power production test results.	M. Hale	Sep 98

DISH/ENGINE ACTIVITIES

The objective of this task is to support the solar thermal industry in developing dish/engine power generation systems for remote power and utility-scale markets. The near-term objective is to build, field, and operate prototype dish/engine systems to establish performance, reliability, and cost databases.

SAIC USJVP

The Phase 2 objective of the SAIC Utility-Scale Joint Venture Program (USJVP) Project team is to deploy five dish/Stirling systems for operation at utility sites. In the near term, the team will build and deploy five second-generation dish/Stirling systems for test and evaluation. The first system is scheduled to be operational in Golden, Colorado, in December 1997; the second and third systems are scheduled for installation at the Arizona Public Service Company Solar Thermal Advanced Research (STAR) Test Facility in March and April 1998; the fourth system is scheduled for installation in Nevada in June 1998; and the fifth system is scheduled to be installed at California State Polytechnic University at Pomona, California, in the fall of 1998. The principal focus of Phase 2 of the project is to begin developing operational, reliability, and O&M databases for dish/Stirling systems.

SAIC USJVP Phase 2

At the planned budget level, we will build and deploy three or four of the planned Phase 2 systems. It is likely that manufacture and installation of the fifth dish/Stirling system for the California Energy Commission and Southern California Edison Company will be delayed until FY99.

With the supplemental funding, we would complete the funding budgeted for Phase 2 of the project and should easily complete the fabrication and installation of all five Phase 2 systems. Testing of the five Phase 2 units would continue through the first quarter of FY99.

SAIC High-Visibility Demonstrations

The objective of this activity is to deploy three high-visibility dish/Stirling systems in the Washington, D.C. area, at a Native American location in the southwest United States, and in Sacramento, California.

Under the base funding level, we will be able to deploy a single system in Washington, D.C. and negotiate a follow-on activity with a Native American tribe.

With supplemental funding, we could deploy an additional system in the Sacramento area and perhaps one at a Native American tribal location.

SAIC Facet Testing

This activity will support facet testing and alignment of the SAIC concentrators. This support will be provided on an as-required basis to the SAIC/Stirling Thermal Motors (STM) dish/Stirling development team.

Joint Venture Program Engine/Receiver Support

In this activity, we will provide engine, receiver, and concentrator support as needed to all industry partners, including the SAIC Joint Venture and the Dish/Engine Critical Components programs. We will provide assistance in the design, development, modeling, and testing of engines, receivers, and concentrators. We will seek opportunities to leverage our expertise and will provide timely support.

Joint Venture Program Hybrid Heat-Pipe Support

In this activity, we will modify our hybrid bench-scale receiver to investigate issues related to hybridizing the STM 4-120 Stirling engine.

We will coordinate efforts with STM to incorporate configuration-specific constraints into the full-scale design and then simulate the full-scale receiver on our bench-scale device. As appropriate, we will incorporate STM-designed burners and recuperator parts and compare results to Sun•Lab hardware.

Dish/Engine Critical Components

This activity is for a new dish/engine development program, similar to the previous joint venture programs, but different in that Phase 1 focuses on establishing the performance of the power conversion system, the engine and receiver, before proceeding to integrate this into a complete system in Phase 2. In addition, this program allows for power systems other than Stirling engines, requires substantial cost share like the joint venture projects, and includes technical support from Sun•Lab.

AlliedSignal Dish/Engine Critical Components

Last fiscal year, Sun•Lab entered into a contract with AlliedSignal to develop a 25- to 30-kW electric dish/engine power generation system. Phase 1 of the project, which is about 13 months duration, is for testing of a solar turbo-generator at Sandia's NSTTF. During Phase 2 of the project, AlliedSignal will integrate the power conversion system with a dish concentrator and test the prototype system. Phase 3, which is an uncosted contract option, is the field deployment of a number of pre-commercial dish/Brayton prototype systems in typical operational environments.

This project is exciting for two important reasons. First, dish/Brayton systems are easily hybridized systems capable of delivering power on demand and thereby increasing their value to the utility. Second, this research and development activity will use components from the turbine generator of a gas-fired generator set that AlliedSignal has recently determined to market as a commercial power generator in partnership with Commonwealth Edison.

During this fiscal year, we expect to complete Phase 1 of the project, on-sun testing of the power conversion system.

Boeing Dish/Engine Critical Components

Sun•Lab is currently negotiating a second dish/engine project with Boeing and Stirling Energy Systems. There are problems with the terms of the proposed contract and the documentation of cost share. If these problems cannot be resolved, the negotiations will be terminated.

AlliedSignal Receiver/Engine Support

In this activity, we will assist AlliedSignal in the design, development, and testing of a suitable receiver and engine/receiver integration for its solar Brayton system. We will provide experience-based design assistance; thermal, optical, and stress analysis; and dish-integration assistance as needed. Our extensive receiver, dish, and integration experience will complement AlliedSignal's engine experience.

AlliedSignal Concentrator Evaluation

During Phase 1 of the project, AlliedSignal will select a solar concentrator manufacturer with whom it will work to develop its Phase 2 system. Sun•Lab will support AlliedSignal in reviewing and evaluating the performance of the proposed solar concentrators.

Validate Prototype Dish/Engine Hardware

In this task, we will work with commercial partners to demonstrate and validate near-term dish/engine technology. The goals of this task are to demonstrate new combinations of existing hardware and benchmark the test results against prior implementations. Some new combinations show promise to break conversion efficiency records or to significantly enhance the system performance. We will provide extensive testing experience, especially in the area of integration issues and instrumentation accuracy.

STM Engine/Heat-Pipe Testing

In this high-visibility activity, we will integrate the updated STM 4-120 Generation-III engine with a Thermacore heat-pipe receiver and test the package on Sun•Lab's test bed concentrator. This effort will demonstrate the performance advantages of a heat-pipe receiver, measure the improvements in STM's engine design, increase STM's confidence in heat-pipe technology, and possibly set a new conversion efficiency mark. STM will supply the updated engine at its cost, and Sun•Lab will supply the receiver.

Ft. Huachuca Heat-Pipe Testing

In this activity, we will integrate a Thermacore 36-kW_t heat-pipe receiver with a

Solo 161 Stirling engine and a CPG-460 concentrator and will compare test results to the prior direct-illumination receiver tests. The concentrator and engine are available under the Strategic Environmental Research and Development Program (SERDP), and Sun•Lab will provide the Thermacore receiver and complete its integration. Solo, Inc., Schlaich-Bergermann und Partner, and Thermacore, Inc. have shown considerable interest in this program.

Next-Generation Dish/Engine Designs

In this task, we will develop next-generation and advanced dish/engine components. The purpose of these new components is to improve performance, improve life, and/or reduce cost over existing designs and hardware. We will pursue medium- to high-risk, high-payoff projects. This year, our efforts will concentrate on receiver and hybridization issues.

Felt-Wick Development

Felt/metal heat-pipe wicks have shown tremendous promise in short-term tests to improve the throughput capability of heat-pipe receivers. However, several lifetime issues have been noted, including corrosion and mass transport, structural stability (crushing), and initial contamination. In this activity, we will investigate solutions to each noted problem and evaluate the solutions in long-term capsule tests, long-term bench-scale tests, and full-scale demonstration units. This effort is critical to the acceptance of heat pipes by the solar-thermal community.

Receiver Materials Support

As we continue to improve the lifetime of dish systems, materials limitations and costs tend to drive development efforts. In this task, we will provide materials analysis, testing, development, and support to the other development efforts. Specifically, we will investigate materials properties and morphology before and after testing, test new materials for compatibility, develop chemical transport models to better understand degradation phenomena in heat-pipe receivers, and run subscale tests to evaluate materials in simulated environments. The materials expertise at Sun•Lab will be applied where needed to materials issues in engines, receivers, and concentrators, including the heat-pipe and Brayton receiver efforts. We will seek outside assistance from world-class experts as needed.

Hybrid Heat-Pipe Development

Sun•Lab, DOE, and our industrial partners have identified hybridization as a critical need for commercialization of dish systems. Introducing heat from a burning fuel into a high-temperature engine is a difficult task. This year, we will complete bench-scale testing of a proposed hybrid heat-pipe design and use the data to finalize a full-scale hybrid heat-pipe design. We will emphasize cost and performance in our design and ensure compatibility with existing engine and receiver hardware designs. As issues arise during the design phase, we will perform appropriate subscale tests to verify design suitability.

Advanced Wick Development

In this task, we will develop advanced heat-pipe wick alternatives that address the observed felt-wick problems without sacrificing felt-wick performance. We will screen sample materials and processes and build subscale heat-pipe tests to verify suitable operation and life. We will support related work in the former Soviet Union as appropriate.

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Major Milestones – Dish/Engine Activities		
Milestone Description	**Staff Responsible**	**Expected Completion**
Install first second-generation dish/Stirling system. (SAIC)	M. Mehos	Dec 97
Begin on-sun testing of STM Generation-III engine with a heat pipe.	S. Rawlinson	Jan 98
Select solar concentrator design for Phase 2. (AlliedSignal)	T. Mancini	Mar 98
Place contract or terminate negotiations with Boeing and Stirling Energy Systems. (Sun•Lab)	R. Diver	Mar 98
Begin on-sun testing of the Solo 161 engine with a heat pipe.	R. Diver	Apr 98
Deliver Brayton power conversion system to NSTTF for testing. (AlliedSignal)	T. Mancini, T. Moss	Apr 98
Begin on-sun testing of a next-generation heat-pipe receiver.	C. Andraka	May 98
Install dish/Stirling system in the Washington, D.C. area. (SAIC)	T. Mancini	May 98
Complete testing of hybrid bench-scale prototype.	M. Bohn	Jun 98
Install dish/Stirling system in Sacramento. (SAIC)	T. Mancini	Jun 98
Complete 750 hours of operation on a Phase 2 dish/Stirling system. (SAIC)	M. Mehos	Jul 98
Complete testing of the Brayton power conversion system. (Sandia and AlliedSignal)	T. Moss	Aug 98
Complete design of full-scale hybrid heat pipe.	J. Moreno	Sep 98

CROSS-CUTTING TECHNOLOGY

Cross-cutting technologies provide advancements that can be applied to power towers, dish/engine systems, and trough plants. Activities included in this section are system analysis, manufacturing, concentrator technology development, materials identification and development, facilities operation and maintenance, and long-term R&D.

Systems Analysis

The objectives of this activity are to develop an improved understanding of STE technologies and their applications, support the analysis of advanced technology concepts, identify ways of reducing capital and O&M costs while increasing performance, and identify the key issues affecting technology commercialization and market identification.

Roadmapping and General Support

The current deregulation of the U.S. utility power industry is resulting in significant changes in the requirements of STE technologies and how they will need to be marketed in the future. As such, our current technology development approach that relies on utilities to purchase initial STE power projects is no longer plausible. Thus, Sun•Lab will form laboratory/industry teams to develop new technology roadmaps for parabolic dish/engine and solar power tower STE technologies. These technology roadmaps will encourage thinking about the technological future and provide a vehicle with which to organize our technology forecasting processes. Technology roadmaps provide a means to inform R&D engineers and sales and marketing personnel about technologies that require development and where applications for future products exist. These roadmaps will be used to guide future R&D planning decisions in the DOE/Sun•Lab Solar Thermal Electric Program.

Solar Resource Assessment – Maps

Solar resource data are critical for siting new STE power plants. There is generally a lack of good-quality direct-normal insolation (DNI) data for most potential international markets. NREL's Resource Assessment group has developed a technique that uses satellite data to generate DNI maps. During FY97, this methodology was used to map DNI resources for India and surrounding regions, the Middle East, and North America. During FY98, we will use this methodology to map DNI resources for one additional international region.

SolMaT

The objectives of SolMaT are to develop manufacturing technology and processes that will (1) permit cost-effective deployments of solar thermal systems in low-volume, early commercial applications; (2) reduce uncertainty in the cost and reliability of key solar components to improve financing of early commercial systems and reduce the risk of performance warranties; (3) promote the development of system-level business plans and industrial partnerships linking manufacturing scenarios to commercial sales prospects; and (4) establish the manufacturing basis for achieving the substantial cost reductions possible through higher volume production. SolMaT 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. During FY98, SolMaT will identify new manufacturers for concentrator drives and provide manufacturing support to industry on an as-needed basis.

SAIC Heliostat Phase 3, Project 1

SAIC will continue to refine its facet manufacturing processes to further reduce facet cost and to further refine its manufacturing cost estimates. A complete facet assembly line will be brought together in a single location for the first time. This assembly line will allow SAIC to produce facets using the line and methods intended for large-scale production for near-term markets. [Supplemental budget only.]

Solar Concentrator Drive Survey and Evaluation

Concentrator drives are a critical and costly component in a dish or a heliostat. This activity addresses using existing, mass-produced gear drive technologies that may be modified as concentrator drives. The intent is to find hardware that could meet concentrator drive needs without incurring mass production setup costs. In FY97, nearly 200 potential suppliers were surveyed. The current activity will focus on about 10 of the best candidates to determine in some detail the potential of their gear drives to meet our needs as concentrator drives.

Peerless/Dodge Drive Development

In this activity, we will evaluate the cost reduction of the Peerless-Winsmith drive through teaming for mass production. With this activity, we hope to leverage the excellent mechanical design of the Peerless drive with established large-scale manufacturers. We will also determine the potential of the Dodge gear drive as a heliostat drive and perform long-term operational evaluation. [Supplemental budget only.]

Industry Support

The activities in this subtask will involve collaborating with the SolMaT team to identify one STE manufacturer to apply Sun•Lab's manufacturing expertise to help obtain the cost, performance, and durability criteria established by the Solar Thermal Electric Program goals. Additionally, in support of our industry partners, we will use computational fluid dynamics to support industry technology development. Applications include those development activities where a detailed understanding of fluid dynamics, heat transfer, or chemical reaction is needed to move forward with hardware design.

Concentrators

The objective of concentrator technology development is to bring heliostat and parabolic dish solar concentrators to commercial readiness for use in STE systems. Heliostats and parabolic dishes provide the "fuel" for STE systems. These two types of solar concentrators comprise similar parts and use similar manufacturing processes; for example, both have an optical surface (typically glass), an optical element support structure, a two-axis drive, and a tracking/control system. Power tower and dish/engine design studies show that the cost of the solar concentrator is 40 to 50% of the cost of these two types of solar systems. The challenge that continues to face us is to reduce the cost of the concentrator while continuing to maintain the high levels of performance that are demonstrated by many of the current designs.

Video SHOT

The Video Scanning Hartmann Optical Tester (Video SHOT) has been under development for two years. This test system has demonstrated the ability to very accurately measure an optical surface in the laboratory. It may also be useful in field applications to align a dish or heliostat and/or measure the potential optical performance of an entire solar concentrator. We will develop the first prototype laboratory/field system during this year.

Wind Load Evaluation

Wind loads define the structural requirements for heliostats and dishes and, consequently, have a large effect on the cost of the concentrators. Previous attempts to characterize the wind loads on solar concentrators have resulted in predictive tools that, in many cases, appear to be very conservative. This activity will measure wind loads on the SAIC heliostat and provide some initial information on how conservative the existing tools are.

Advanced Materials

The objectives of the materials task are to identify and develop advanced materials for solar thermal applications that meet industry's goals of cost, performance, and durability. We will carry out these objectives by performing testing, characterization, and evaluation of candidate advanced materials; by collaborating with the solar and materials industries to develop and test advanced materials of near- and long-term interest; and by conducting long-term research and analysis to better understand the fundamental properties that influence advanced material performance. The success of the program's near-term goals hinges on durability issues. Such systems must survive and operate reliably for extended lifetimes. The long-term success of STE systems depends upon the systems' economic viability. Dramatic cost reductions, as may be achieved by new advanced materials, are needed.

Advanced Reflectors

Under this subtask, we will identify and develop candidate advanced reflector materials that meet the solar thermal industry's goals of cost, performance, and durability. We will continue a promising subcontracted activity for development of an alumina-overcoated silver mirror. We will construct prototype solar mirrors for further evaluation using a new vacuum deposition system. Our interactions with the vacuum coating industry will continue to allow advances within that industry to be incorporated into development activities and to ensure viable process scale-up of advanced reflector candidates.

Service Lifetime Prediction

We will develop and validate a general methodology to allow prediction of service lifetimes applicable to any and all STE technology-related materials, components, and systems. Such a capability will allow quantification of O&M and reliability analyses and increase the confidence of prospective solar manufacturers in systems/products and warranties/life cycle cost projections. We will accomplish this activity by building upon previously developed capabilities that encompass sample preparation, performance characterization, outdoor weathering, accelerated exposure testing, analytical techniques allowing failure mechanistic studies, and model development including statistical analysis.

Advanced Absorbers

We will identify and develop candidate advanced absorber materials that meet the solar thermal industry's goals of cost, performance, and durability. Improved absorbers reduce capital and O&M costs and increase delivered energy of solar thermal systems. This activity will build upon the low-temperature absorber expertise at Sandia. Under Sandia's extended CRADA with Energy Laboratories, Inc., we will evaluate a promising low-temperature absorber coating for higher temperature applications. We will also investigate other innovative higher temperature absorber material systems.

Industry Support

In this activity, we will provide characterization, testing, and analysis capabilities of materials and components that are routinely requested by the STE industry. We will participate in industry review meetings and provide advice on materials and designs. We will perform and document requested performance characterizations (optical, thermal, mechanical, etc.) and durability testing (weathering and hail impact).

Facilities

The objective of facilities support is to operate and maintain the Sandia National Solar Thermal Test Facility and the NREL High-Flux Solar Furnace in support of the Solar Thermal Electric Program objectives.

Operations

Operating tasks include purchasing material and equipment for testing, calibrating test equipment, inventorying equipment, waste management, shipping and receiving, and reapplication of equipment and materials.

Maintenance

We will maintain site test equipment for testing. A portion of this budget will go toward maintaining the heliostat field and the test bed concentrators.

Environment, Safety, and Health

We will ensure compliance and continued excellence with laboratory and national environment, safety, and health regulations.

Facilities Space

These costs cover Sandia's internal costs for support of facilities.

Long-term Research and Development

Long-term R&D is intended to provide the basis for new STE technologies. Through solicitations within and outside Sun•Lab, the project seeks the best ideas and supports proof-of-concept analyses or testing. Projects for which the concept can be proven are moved forward to field testing at Sun•Lab facilities and are expected eventually to become mainstream R&D activities within the program.

STAR

In FY98, Solar Thermal Advanced Research (STAR) will solicit within and outside Sun•Lab for two additional ideas for STE conversion technologies. This will bring to four the number of high-risk R&D projects supported under STAR. The new solicitation will focus on technologies that differ significantly from our mainline R&D areas but have potential to supply solar thermal electricity at low cost or to open new markets for STE.

Major Milestones – Cross-Cutting Technology

Milestone Description	Staff Responsible	Expected Completion
Complete installation of wind-load instrumentation for the SAIC heliostat.	A. Lewandowski	Nov 97
Identify manufacturer for industry assistance.	P. Cordiero	Apr 98
Complete SAIC Phase 2 Project and document heliostat cost reductions of 25%.	A. Lewandowski	May 98
Complete drive design modifications evaluation.	B. Kolb	Jun 98
Complete technology roadmap for solar power tower.	H. Price	Jun 98
Complete technology roadmap for dish/engine systems.	H. Price	Jun 98
Complete DNI map for international location.	H. Price	Jun 98
Complete Video SHOT dual laboratory and field system.	S. Jones	Jul 98
Start one new STAR project.	M. Bohn	Aug 98
Report on manufacturing assistance.	P. Cordiero	Sep 98
Develop two new reflector materials with low-cost potential and a lifetime (as measured by accelerated weathering tests) greater than ECP-305+.	G. Jorgensen	Sep 98
Apply Service Lifetime Prediction methodology to three solar mirror materials.	G. Jorgensen	Sep 98
Develop a new mid-temperature (approximately 400°C) solar absorber material with low-cost potential and thermal stability extrapolated (from accelerated test results) beyond 5000 hours.	R. Mahoney	Sep 98

CROSS-CUTTING SUPPORT

Cross-cutting support activities address issues and needs that are common to all STE technologies. These include activities such as developing an understanding of the power market's requirements and developing the communication tools that will provide access to STE technical information.

Market Opportunities and Barriers/Identify First Customers

In the past, the DOE Solar Thermal Electric Program focused on developing STE technologies that would be purchased and operated by vertically integrated power utilities. Given the current deregulation and restructuring of the domestic power utilities, it is unlikely that utilities will be the primary customer of STE technology in the future. The objectives of this activity are to identify new market opportunities for STE technologies, develop an in-depth understanding of the requirements of those markets, and identify potential barriers that may exist for STE technologies.

Project Development Team – Operation Thunderball

A new activity was established this year to help us better understand what is required to get STE technologies to the markets. Entitled "Operation Thunderball," the purpose of this initiative is to ensure that the technology development activities of the DOE Solar Thermal Electric Program have the most current information on the revolution taking place in the domestic and international electric power industry. In the first stage of the project, the Thunderball team will interview key power sector participants in an attempt to better understand future markets and how the key players are positioning themselves for these markets. Following this discovery phase of the project, the team will identify and enable opportunities for the development of early STE projects, provide information on the status of markets and opportunities to industry, seek new initiatives and approaches to improve the competitive position of STE systems in the markets, and identify and nurture key government-industry partnerships to foster long-term business development.

SolarPACES START Missions

International Energy Agency/SolarPACES has created Solar Thermal Analysis, Review and Training (START) missions to provide technical outreach to many international locations that are prime candidates for STE technologies. The START team visits selected countries to brief research centers, electric utilities, and the energy ministries regarding the technoeconomic status of solar thermal technologies and to explore the possibility of building large solar thermal power plants. The focus for FY98 will be to complete two additional new or follow-on START missions.

Communications

The major objective for the Sun•Lab Communications team is to create effective communication products for the DOE Solar Thermal Electric Program. These products include graphic materials for displays and exhibits; printed materials, such as brochures, reports, and fact sheets; videos and still photos; marketing materials; and material for the World Wide Web. The team works with Sun•Lab management and staff to create these products to provide information about the mission, policy, technologies, and research of the Solar Thermal Electric Program. The team includes industry partners as appropriate in creating these materials.

Sun•Lab Communications

The Communications team will supply exhibit and publications support to Sun•Lab management and staff during the year, including preparing internal documents (the Annual Operating Plan, Quarterly Reports, and Highlights). We will coordinate creation and approval of communications products with DOE and industry when appropriate.

Web Site Development

Based on suggestions of topics from management and staff, we will develop four new fact sheets that will form a set with the sheets in existence to create a folder of information about the Solar Thermal Electric Program. These fact sheets, along with other program documentation, will be published electronically at the Sun•Lab site on the World Wide Web. The Sun•Lab web site will become a primary means of communication for the program.

Publications and Outreach Support

The Solar Energy Industries Association publishes the *Solar Industry Journal* quarterly, and the team will provide input for each issue about Sun•Lab work. As opportunities arise, we will provide input to *FEMP Focus* and to the newly created *Solar Reflections*. We will prepare displays and (weather and operations permitting) a video supporting Solar Two operations.

Soltech '98

In collaboration with technical staff and management, we will develop a display and related exhibit materials for Soltech '98, scheduled April 25 through 30, 1998, in Orlando, Florida. We will provide support for the display booth as needed and will make all the logistical arrangements for the display materials at the meeting.

Major Milestones – Cross-Cutting Support

Milestone Description	Staff Responsible	Expected Completion
Provide input for the *Solar Industry Journal.*	A. Van Arsdall	Quarterly during FY98
Provide exhibit materials and support for Soltech '98.	A. Van Arsdall	Apr 98
Create visitor information materials at Solar Two.	A. Van Arsdall	Feb 98
Create a video on Solar Two to show its operational capabilities.	J. Jones	Sep 98
Create four new fact sheets about projects within the Solar Thermal Electric Program.	J. Jones	Sep 98
Support one SolarPACES START mission.	G. Kolb	Sep 98
Identify and implement three activities to facilitate development of an STE project.	T. Mancini	Sep 98

MAJOR MILESTONES – FY98			
Activity	**Milestone Description**	**Staff Responsible**	**Expected Completion**
Cross-Cutting Support	Provide input for the *Solar Industry Journal.*	A. Van Arsdall	Quarterly during FY98
Cross-Cutting Technology	Complete installation of wind-load instrumentation for the SAIC heliostat.	A. Lewandowski	Nov 97
Power Tower	Complete the 100-hour Solar Two plant acceptance test.	M. Prairie	Dec 97
Dish/Engine	Install first second-generation dish/Stirling system. (SAIC)	M. Mehos	Dec 97
Power Tower	Document results of the Solar Two Test and Evaluation Program for 1997.	M. Prairie	Jan 98
Power Tower	Enter the Power Production Phase of Solar Two.	H. Reilly	Jan 98
Dish/Engine	Begin on-sun testing of STM Generation-III engine with a heat pipe.	S. Rawlinson	Jan 98
Cross-Cutting Support	Create visitor information materials at Solar Two.	A. Van Arsdall	Feb 98
Dish/Engine	Select solar concentrator design for Phase 2. (AlliedSignal)	T. Mancini	Mar 98
Dish/Engine	Place contract or terminate negotiations with Boeing and Stirling Energy Systems. (Sun•Lab)	R. Diver	Mar 98
Power Tower	Complete and document the Solar Two steam generation system characterization test.	J. Pacheco	Apr 98
Dish/Engine	Begin on-sun testing of the Solo 161 engine with a heat pipe.	R. Diver	Apr 98
Dish/Engine	Deliver Brayton power conversion system to NSTTF for testing. (AlliedSignal)	T. Mancini, T. Moss	Apr 98
Reliability	Complete the KJC Operating Company O&M Improvement Program and document the final results.	G. Kolb	Apr 98
Cross-Cutting Technology	Identify manufacturer for industry assistance.	P. Cordiero	Apr 98
Cross-Cutting Support	Provide exhibit materials and support for Soltech '98.	A. Van Arsdall	Apr 98
Power Tower	Complete testing of the Boeing panel.	J. Pacheco	May 98
Dish/Engine	Begin on-sun testing of a next-generation heat-pipe receiver.	C. Andraka	May 98
Dish/Engine	Install dish/Stirling system in the Washington, D.C. area. (SAIC)	T. Mancini	May 98

Activity	Milestone Description	Staff Responsible	Expected Completion
Cross-Cutting Technology	Complete SAIC Phase 2 Project and document Heliostat cost reductions of 25%.	A. Lewandowski	May 98
Power Tower	Complete and document the Solar Two receiver efficiency test.	J. Pacheco	Jun 98
Power Tower	Present results of the hybrid study at the Roadmapping Workshop.	T. Williams	Jun 98
Dish/Engine	Complete testing of hybrid bench-scale prototype.	M. Bohn	Jun 98
Dish/Engine	Install dish/Stirling system in Sacramento. (SAIC)	T. Mancini	Jun 98
Trough Development	Complete parabolic trough roadmap.	H. Price	Jun 98
Trough Development	Document fluid degradation resolution plans.	R. Mahoney	Jun 98
Cross-Cutting Technology	Complete drive design modifications evaluation.	B. Kolb	Jun 98
Cross-Cutting Technology	Complete technology roadmap for solar power tower.	H. Price	Jun 98
Cross-Cutting Technology	Complete technology roadmap for dish/engine systems.	H. Price	Jun 98
Cross-Cutting Technology	Complete DNI map for international location.	H. Price	Jun 98
Power Tower	Demonstrate dispatchability: generate electricity with Solar Two for three hours after dark at maximum power output.	H. Reilly	Jul 98
Dish/Engine	Complete 750 hours of operation on a Phase 2 dish/Stirling system. (SAIC)	M. Mehos	Jul 98
Cross-Cutting Technology	Complete Video SHOT dual laboratory and field system.	S. Jones	Jul 98
Dish/Engine	Complete testing of the Brayton power conversion system. (Sandia and AlliedSignal)	T. Moss	Aug 98
Cross-Cutting Technology	Start one new STAR project.	M. Bohn	Aug 98
Power Tower	Complete characterization of SAIC's heliostat at the NSTTF.	J. Grossman	Sep 98
Power Tower	Document Solar Two power production test results.	M. Hale	Sep 98
Dish/Engine	Complete design of full-scale hybrid heat pipe.	J. Moreno	Sep 98
Trough Development	Complete Sun•Lab input to SolWin.	H. Price	Sep 98
Reliability	Monitor reliability at Solar Two and recommend solutions to reliability problems.	G. Kolb	Sep 98

Activity	Milestone Description	Staff Responsible	Expected Completion
Cross-Cutting Technology	Report on manufacturing assistance.	P. Cordiero	Sep 98
Cross-Cutting Technology	Develop two new reflector materials with low-cost potential and a lifetime (as measured by accelerated weathering tests) greater than ECP-305+.	G. Jorgensen	Sep 98
Cross-Cutting Technology	Apply Service Lifetime Prediction methodology to three solar mirror materials.	G. Jorgensen	Sep 98
Cross-Cutting Technology	Develop a new mid-temperature (approximately 400°C) solar absorber material with low-cost potential and thermal stability extrapolated (from accelerated test results) beyond 5000 hours.	R. Mahoney	Sep 98
Cross-Cutting Support	Create a video on Solar Two to show its operational capabilities.	J. Jones	Sep 98
Cross-Cutting Support	Create four new fact sheets about projects within the Solar Thermal Electric Program.	J. Jones	Sep 98
Cross-Cutting Support	Support one SolarPACES START mission.	G. Kolb	Sep 98
Cross-Cutting Support	Identify and implement three activities to facilitate development of an STE project.	T. Mancini	Sep 98

DOE/EE Solar Thermal Electric Program

Priority level: Base / Suppl
Total ($M): $16.78 / $18.60

Totals for Base Planning Level

FY98 Budget - Final AOP Guidance at $16.8M w/ possible supplement	B&R	Sandia FTE$	Sandia Contr	Sandia Total	NREL FTE$	NREL Contr	NREL Total	DOE Org	DOE Total	Total FTE$	Total Contr	Total Total
Solar Thermal Electric Total		5076	3766	8842	1973	509	2482		5451	7049	9726	16775
Thermal Systems Research EB23-1101		2444	1539	3983	1086	284	1370		0	3530	1823	5353
Power Applications Devel EB23-1102		2632	2227	4859	887	225	1112		5451	3519	7903	11422
Power Tower Activities		1764	887	2651	424	85	509		2500	2188	3472	5660
Solar Two Testing	2	938	465	1403	200	45	245	GO	2500	1138	3010	4148
Validate Prototype PT Hardware	1	767	410	1177	47	3	50		0	814	413	1227
Hybrid Molten Salt Components	1	59	12	71	177	37	214		0	236	49	285
Dish/Engine Activities		1834	1796	3630	399	80	479		0	2233	1876	4109
SAIC USJVP	2	296	710	1006	236	40	276		0	532	750	1282
DECC	2	609	805	1414	0	0	0		0	609	805	1414
Validate Prototype D/E Hardware	1	200	133	333	0	0	0		0	200	133	333
Next-Generation D/E Designs	1	729	148	877	163	40	203		0	892	188	1080
Trough Development Activities		117	50	167	100	50	150		0	217	100	317
Trough Technology Development	2	117	50	167	100	50	150		0	217	100	317
Reliability Activities		15	2	17	0	0	0		0	15	2	17
Improve System Reliability	2	15	2	17	0	0	0		0	15	2	17
Cross-Cutting Technology		923	921	1844	949	274	1223		0	1872	1195	3067
Systems Analysis	2	150	10	160	235	55	290		0	385	65	450
SolMat	2	84	75	159	15	15	30		0	99	90	189
Concentrators	1	165	30	195	99	35	134		0	264	65	329
Materials	1	94	21	115	535	99	634		0	629	120	749
Facilities	1	395	730	1125	30	15	45		0	425	745	1170
Long-Term R&D	1	35	55	90	35	55	90		0	70	110	180
Cross-Cutting Support		423	110	533	101	20	121		2951	524	3081	3605
Markets / Customers	2	150	30	180	34	0	34		0	184	30	214
Communications	2	173	80	253	67	0	67		0	240	80	320
Management	2	100	0	100	0	20	20		2951	100	2971	3071

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