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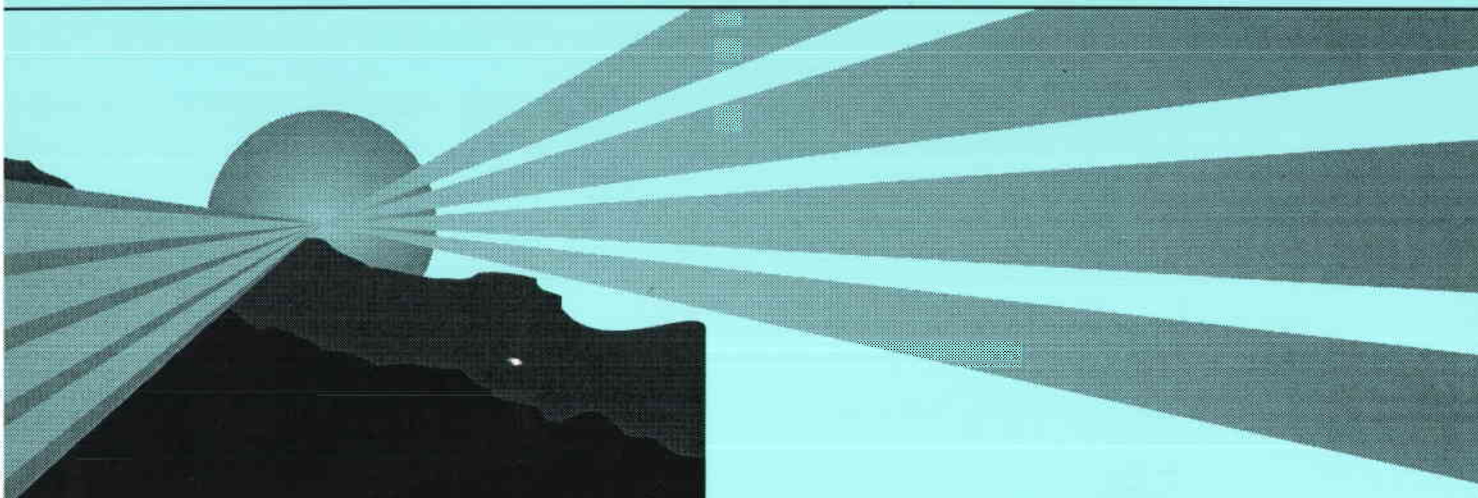

CONCENTRATING
SOLAR POWER
PROGRAM

Annual Operating Plan

Fiscal Year 1999

U.S. Department of Energy

CONCENTRATING • SOLAR • POWER

Sun•Lab

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

October 1998

Operated for the United States Department of Energy

FOREWORD

In FY98, we completed a new Five-Year Plan for the Concentrating Solar Power Program, and FY99 marks the first year that our Annual Operating Plan planning process has been based directly on this plan. Areas of increased emphasis include dish/engine reliability, dispatchable technology cost reduction, and advanced development. Key new activities include development of a new dish/engine remote power system, initiation of new trough component development efforts, and enhanced market development efforts. Activities in support of Solar Two, the Utility-Scale Joint Venture Program and Dish/Engine Critical Component activities, and advanced development will continue. We will continue to pursue potential domestic and international project opportunities to help bring concentrating solar power into the commercial arena.

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INTRODUCTION

Concentrating solar power (CSP) technologies (previously referred to as solar thermal electric technologies) use mirrors to concentrate the sun's energy up to 10,000 times to power conventional turbines or heat engines to generate electricity. This clean, secure, environmentally friendly power diversifies our domestic electricity production options and has the potential for major impacts in international markets. Energy from CSP systems is high-value renewable power because energy storage and hybrid designs allow it to be provided on-demand—even when the sun is not shining.

Future deployment of CSP technologies can substantially reduce greenhouse gas emissions. The rapid increases in annual production capacity achieved during the construction of existing plants (up to 80 MW/year) have demonstrated the capability of CSP production, with modest manufacturing capacity investment, to rapidly expand in order to provide huge quantities of power at prices that in the long term will compete directly with conventional fossil technologies. These technologies feature additional advantages of providing quality manufacturing jobs for local economies and export markets for key components.

Meeting our goals will be a challenge. We believe, however, that the combined capabilities of the Department of Energy (DOE), Sandia National Laboratories and the National Renewable Energy Laboratory (working together as Sun•Lab), and U.S. industry are up to that challenge, and hence that CSP can become a major source of clean, reliable, and secure power in the future.

OUR VISION

Our vision for success of the Concentrating Solar Power Program is world leadership by U.S. industry in supplying 20 GW of concentrating solar power by 2020.

OUR MISSION

Our mission within the DOE's Concentrating Solar Power Program is to help provide for the energy, economic, and environmental security of the United States. We will fulfill our mission through technology research, development, and field validation required for CSP technologies to make a major contribution to clean global energy resources in the years to come.

OUR OBJECTIVE

Our objective is to develop and validate CSP technologies that meet the needs of the marketplace. Building on the success established to date, we expect to make significant progress in the next five years by focusing on the following four paths

- Developing and demonstrating high-reliability distributed power systems;
- Reducing costs of dispatchable solar power;
- Developing advanced components and systems; and
- Expanding strategic alliances and market awareness.

OUR STRATEGIES

Our strategies for achieving our objective are to

- Focus on the reliability of dish/engine systems for emerging markets for distributed energy sources. Efforts in this area address the technology improvements needed to field more competitive next-generation systems. The efforts will result in orders of magnitude improvements in system reliability and will achieve energy costs in the range of 9 to 11¢/kWh in about five years.

- Address the highest priority activities required to bring commercially proven trough and demonstration power tower technologies to early dispatchable power markets. Accompanied by early demonstrations supported by both green power markets and multilateral organizations like the Global Environment Facility, this development effort will lead to a "next generation" of plant designs capable of producing dispatchable power for 6 to 8¢/kWh by 2003.

- Penetrate broad domestic and international megamarkets. Coupled with economies-of-scale emerging from continued expansion into high-value markets, the advanced technologies resulting from this path will allow CSP systems to compete in large-scale distributed and dispatchable markets priced at 4 to 6¢/kWh. At these prices, U.S. industry will ultimately be able to achieve our strategic target of 20 GW by 2020.

- Keep our technology efforts focused on the most critical needs of industry, ensure a technology capable of meeting market requirements, and support domestic and international information flow and policy decisions favorable to renewable energy.

PERFORMANCE MEASURES

FY99 Planned Accomplishments

- Complete Solar Two testing, including demonstrating a reduction in parasitic power use from 25 MWh/day to the design goal of 11 MWh/day.

- Accumulate 750 hours of reliable operation on a single distributed CSP system.

- Initiate collaboration with U.S. industry for research and development of trough systems.

    - Develop and demonstrate a lightweight structural facet that will decrease the cost and increase the reliability of concentrators for both distributed and dispatchable solar power systems.

FY00 Planned Accomplishments

- Have U.S. trough team use DOE-advanced technology in a competitive project bid.

- Achieve 1,000 hours of autonomous operation on a single dish/engine system in field testing.

- Develop off-grid capability for remote CSP systems and begin testing on a Native American site.

- Build the first advanced Dish/Engine Critical Components distributed solar power system and begin field tests.

PATH 1: DISTRIBUTED POWER

Our primary goal in this path is to achieve significant improvements in the reliability of U.S.-manufactured distributed CSP systems. We will develop these systems to be the most reliable products of their type in the world and will verify this reliability through a series of field validations. The reliability and operating characteristics proven in the field will provide the critical data required by investors and end users prior to early commercial introduction of the technology. Significant reductions in the cost of the technology will also occur during this time but will be pursued as a secondary objective relative to establishing market-ready reliability.

Utility-Scale Joint Venture Program

The current major project in this area is the Utility-Scale Joint Venture Program (USJVP), the objective of which is to develop manufacturable 25-kW dish/Stirling systems ready for commercial demonstration. This project cost is shared on a 50/50 basis by industry (Science Applications International Corporation [SAIC], STM Corp., and Arizona Public Service Company) and the DOE. The next USJVP project milestone will result in the testing of three "second-generation" system designs that show significantly improved reliability and availability compared to the first-generation system built by the team.

Washington, D.C., System

After an additional two months of operating the SAIC 25-kW solar dish/engine system in Washington, D.C., we will remove it in early December.

SAIC Phase 2X Systems

We will test three second-generation dish/Stirling systems in Golden, Colorado, and Phoenix, Arizona, for one year. This testing will allow us to establish the reliability of the SAIC dish/Stirling system in solar and hybrid modes of operation. Our goals are to operate three systems, achieve 750 hours autonomous operation of one system, achieve a mean time between failures (MTBF) greater than 500 hours, and generate 50,000 kWh.

Dish/Engine Critical Components

Another system-level effort led by industry teams is the Dish/Engine Critical Components (DECC) Project. The objective of this effort is to develop alternative components for the "solar critical" parts of a dish/engine system to provide technology options and diversify the applications that can be served by U.S. industry. The current projects in this area include cost-shared development of solar dish systems using Brayton- and Stirling-cycle heat engines. Early work will solarize and test these engines, with follow-on activities aimed at integrating the engines into complete systems. We will develop additional, similar contracts under the DECC Project in the future.

Boeing DECC Phase 1

We will characterize the Boeing North American/ Stirling Energy Systems (Boeing/SES) 4-95 power conversion unit (PCU) reliability with on-sun and gas-fired bench testing. We will document reliability characterization of refurbished Boeing/SES 4-95 PCUs. Our goal is 2,500 on-sun hours through FY99 and greater than 90% availability.

Boeing DECC Phase 2

We will initiate development of a new and updated Boeing/SES dish/Stirling system, including modification to the concentrator, engine, and controls. This system is a proven and reliable dish/Stirling system option for commercialization opportunities in the United States. In addition, we will increase the number of Phase 1 on-sun and gas-fired bench test units, which will result in faster development of the Boeing/SES dish/Stirling system.

AlliedSignal DECC Phase 1

We will terminate our current AlliedSignal DECC contract with AlliedSignal's Aerospace Equipment Systems group. We will reinitiate the AlliedSignal DECC contract with Power Systems, Inc. by October 1999.

Reliability Improvement

The purpose of this task is to improve the reliability of current and future CSP technologies. Engine reliability is currently a critical issue, with industry working to develop enhanced solar designs and DOE activities focused on validating engine operations in field testing and diagnosis of problem areas. Current efforts also emphasize developing new receivers for higher efficiency operation (primarily liquid metal heat-pipe receivers) while resolving materials and fabrication problems that have limited the lifetime and reliability of the prototype units tested to date.

SAIC Component Improvement

Improved dish/engine system reliability is the focus of our development program. We will focus on development of more reliable control systems for dish/engine systems. We expect increased MTBF of controls to 750 hours.

Dish/Engine Support Activities

We will proactively support the Joint Venture Program and the DECC Program on an as-needed basis. We will apply Sun•Lab expertise and experience to solve current problems and enhance the systems, including alignment, infrared camera test support, analysis, materials testing, emissions, reflective film analysis, and so forth. Partners can tap into unique capabilities of the laboratories to enhance their systems and solve technical problems.

Cost Reduction/SolMaT

As a result of budget limitations, no activities are funded in this area in FY99.

Remote Power System

The high value of distributed power (as high as 50¢/kWh and above for some remote applications) provides many opportunities for commercial deployment early in the technology development. As technology development proceeds, there will be numerous opportunities for field validations that will build on the high value of energy for remote applications and the low cost for system demonstration (because of the small module size). The project objective is to fabricate, demonstrate, and field a fully integrated, stand-alone 10-kW dish/Stirling solar power generation system for use at a remote, off-grid site on a Native American or other remote site in the United States.

Remote Power System

We will provide Sun•Lab support for activities related to the procurement, integration, and testing at the National Solar Thermal Test Facility (NSTTF) of a 10-kW dish/Stirling system in a grid-connected mode. We will capture concentrator and control system developments made by Cummins in the Dish/Stirling Joint Venture and Utility-Scale Joint Venture Programs. We will also provide Sun•Lab staff with hands-on experience in the integration and operation of a dish/Stirling system.

Major Milestones – Path 1: Distributed Power		
Milestone Description	**Staff Responsible**	**Expected Completion**
Place Phase 2X contract with SAIC.	T. Mancini	Feb 99
Install two USJVP systems in Phoenix.	T. Mancini	Mar 99
Place Phase 2 of Boeing DECC contract.	R. Diver	Jul 99
Complete 1,500 total hours on two systems.	T. Mancini	Sep 99
Complete initial testing of a fully integrated 10-kW dish/Stirling system in grid-connected mode at the NSTTF.	J. Muir	Sep 99

PATH 2: DISPATCHABLE POWER

Low energy costs are the overriding criteria in the dispatchable power market, and this path focuses on reducing the levelized energy cost (LEC) of dispatchable solar power. This focus recognizes that while there will be market preferences for renewable electricity such that "green electricity" can be sold at a premium price, the price will still be the most important issue for success in this market. The outcome from this work will be substantial decreases in the LEC of dispatchable power systems. While the systems will not compete broadly with fossil technologies in five years, they will make progress toward substantial commercial deployment in niche markets and be fully competitive with fossil fuels in the longer term.

For dispatchable CSP applications, the LEC is driven by project financing costs, capital investment and net efficiency of the plant, plant availability, and operating costs. Our emphasis in this path focuses on technology aspects under our control: reducing the cost of solar components, reducing technical risk through system testing and field validation, and reducing operation and maintenance (O&M) costs.

Solar Two

The objective of this task is to provide technical and financial support to the Solar Two demonstration project to ensure that the project successfully demonstrates and validates molten-salt power tower technology on a pilot scale. We will use information derived from Solar Two to guide future technology development efforts and to plan, evaluate, and design future power tower projects.

Plant Operations

This task funds DOE's 80% cost share of plant O&M and management as part of the participation agreement with Southern California Edison Company. The O&M contractor, Energy Services, Inc., will provide a well-maintained facility with which the Solar Two test and evaluation (T&E) can be completed. The plant will be able to operate through about April 1999 with a high degree of reliability and availability so all the T&E objectives can be met.

On-Site and T&E Coordination

Coordination of all T&E and other Sun•Lab support will be provided with plant operations, including on-site project engineering, T&E leadership, and interactions with plant personnel and management to coordinate all efforts. Engineering issues will be addressed in a timely fashion. Through this activity, Sun•Lab activities will be well integrated with O&M and project management with no major personnel problems so that all T&E can be completed and the project can meet its objectives.

Test and Evaluation

Sun•Lab staff will be able to complete all planned T&E activities in cooperation with plant operations. These activities will be documented and the plant will be characterized sufficiently to implement optimization strategies.

Technical and Maintenance Support

In this task, Sun•Lab will provide heliostat maintenance and salt system support to improve operational availability and reliability. The goal is to produce 75% of SOLERGY predictions on selected days and improve the overall plant availability.

Salt Chemistry

Sun•Lab will consult with the Solar Two Project on salt-chemistry-specific issues. We will complete stress corrosion cracking studies, reprocess spilled salt, and analyze salt samples. Through this task, we will resolve metallurgical issues, reduce cleanup cost, and demonstrate recycling of spilled salt.

Power Tower Technology

System testing and field validation are both very important in moving toward new commercial applications of dispatchable CSP technology. The magnitude of the capital required for a commercial plant makes investors averse to deployment of any technology that is not well proven. Power tower technology is currently undergoing system tests necessary prior to field validation in a commercial environment.

Test Long-Shafted Hot Pump

In this task, we will complete testing of an advanced hot-salt pump. The majority of testing will be conducted in an automated sequence. Demonstrating this long-shafted hot pump will allow a much simpler, less expensive, more reliable thermal storage system to be designed.

Conceptual Design Basis Document for Next Plant

Bechtel Corporation, the architect and engineer for Solar Two, will develop a conceptual design basis document for the next molten-salt power plant (150-MW hybrid) incorporating lessons learned from Solar Two. At the base-funding level, the conceptual design will be started, taking advantage of experience gained from Solar Two.

Trough Technology

Parabolic troughs are the most commercially proven CSP technology and they continue to offer the lowest cost solar power option available for power markets today. The primary focus of the FY99 activities will be to initiate the USA Trough subcontract to address near-term research and development issues and help make trough technology competitive in today's power market. In addition, Sun•Lab will continue to provide technical support and help facilitate O&M technology transfer between the existing solar electric generating systems (SEGS) projects to support the continued operation of existing projects.

USA Trough Phase 1

This project is an initiative to bring together an industry consortium to aggressively pursue parabolic trough development projects and begin addressing key technology issues for near-term deployment. This effort will provide a mechanism for continued development of parabolic trough technology, build U.S. industry and content, and provide a mechanism for U.S. players to collaborate with international development.

Likely topics are improved trough design, advanced design, and cost-reduction analysis. We will improve performance and reduce the cost of the next plant. We will also reduce risk and increase the likelihood for future trough plant development. Our goal is to reduce the LEC from an 80-MW trough plant by 10%.

Industry Assistance

We will provide technical support to the existing SEGS facilities. We will focus on key issues facing aging plants, such as low-cost heat-collection elements and mirror replacements, mirror life extension, and heat-transfer fluid filtration. Our tasks will provide insight into lifetime and O&M issues that are important for all CSP technologies and will allow us to showcase our existing facilities. Our goal is improved performance and economics of existing facilities.

Cost Reduction/SolMaT

Designing better production methods for solar components will continue in the Solar Manufacturing Technology (SolMaT) initiative. SolMaT works hand-in-hand in cost-shared collaborations with U.S. industry to improve the manufacturing processes for solar-specific components. SolMaT addresses the gap that exists between the potential for low costs in mass production and the current reality of uncertain orders for modest production levels.

During the next five years, SolMaT activities will focus on the highest-cost, most-critical elements of CSP systems. A major focus will continue to be reducing the costs of concentrators for troughs and towers (including reflective surfaces, mirror modules, drives, and structures).

SAIC SolMaT Heliostat Test and Document

We will complete optical testing of SAIC's SolMaT heliostat at the NSTTF and document optical performance of this new heliostat design.

Major Milestones – Path 2: Dispatchable Power

Milestone Description	Staff Responsible	Expected Completion
Complete Solar Two plant parasitic tests.	G. Kolb	Jan 99
Complete optical testing of SAIC's heliostat and produce draft report.	J. Grossman	Mar 99
Complete critical testing at Solar Two.	J. Pacheco	Apr 99
Award USA Trough Phase 1 contract.	H. Price	May 99
Complete Solar Two plant performance evaluation.	J. Pacheco	Jun 99
Extend USA Trough Phase 2 contract.	H. Price	Jul 99
Test heliostat adaptive tracking algorithm.	S. Jones	Sep 99
Document Solar Two test and evaluation activities.	J. Pacheco	Sep 99
Complete LS-3 collector performance test.	R. Mahoney	Sep 99
Apply Black Crystal absorber coating to heat-collection elements.	R. Mahoney	Sep 99
Complete hot-salt pump testing.	J. Pacheco	Oct 99

PATH 3: ADVANCED COMPONENTS AND SYSTEMS

The objective of this path is to develop and validate the advanced technologies that can achieve significant reductions in the future cost of CSP. These technologies are necessary to achieve our long-term strategic goal of competing with the cost of fossil energy in a wide variety of market applications.

Systems Analyses

Systems analyses activities are conducted to evaluate the status of research and development efforts and to identify promising new directions for technology development. Interfacing with the technology roadmapping efforts described in Strategic Alliances and Market Awareness will be one key activity in this area. Systems analyses efforts will also investigate system modeling and optimization, maintaining and updating CSP technology characterizations and detailed system-level evaluations similar to the Utility Studies and Second-Generation Power Tower Studies completed several years ago.

General Systems Analysis

We will develop an improved understanding of CSP technologies and their applications, support the analysis of advanced technology concepts, and identify ways of reducing capital and O&M costs while increasing performance. This task will help us focus our technology development activities on key technology development issues.

Concentrators

Developing new, low-cost designs for solar components is another way to reduce system costs. Of primary importance is the solar concentrator, which represents 40 to 50% of the cost of the power plant. Better reflective materials, mirror facets, structural designs, and drives are all promising avenues leading toward cost reduction. Reflective materials are a particularly promising long-term option because advanced materials hold promise for not only being cheaper than glass mirrors, but for reducing other aspects of concentrator cost by being much lighter in weight and easier to use in manufacturing environments. Field tests of new concentrator designs with analysis of the impacts of wind loads will lead to better design criteria, allowing optimization of concentrator designs and reductions in structural costs.

Advanced Reflectors

We will identify and develop advanced reflector materials for CSP applications that meet industry's goals of cost, performance, and durability. Improved reflector materials benefit all CSP technologies by reduced capital and O&M costs and increased delivered energy. We will work toward developing at least two new promising advanced reflector materials.

Reliability Testing

We will establish durability data of candidate reflector and absorber materials exposed to outdoor and accelerated test environments. The correlation between these results allows us to project service lifetimes. This data will quantify O&M and reliability analyses, increase the confidence of prospective solar manufacturers in CSP systems and products, and act as a catalyst for improvements in product performance.

Optical Materials Manufacturing Process Scale-Up

We will scale-up an advanced reflector material based on ion-assisted alumina protected mirrors developed by SAIC in McLean, Virginia. Samples of this advanced reflector material have demonstrated exceptional durability. Scale-up allows larger area test articles for field evaluation and increases confidence in the manufactured product.

Structural Facets

With industry cost share, we will develop processes and identify manufacturer(s) to produce the structural facets for the internal Concentrating Solar Advanced Research program. The result will be a durable and cost-effective mirror option for troughs, heliostats, and dishes. Our goal is to install more than 200 prototype facets at the SEGS facilities in California.

Drive Development

Because low-cost drives are needed for dishes and heliostats, we will work with Winsmith to reduce costs and complete evaluation of other potential drive manufacturers. We will establish a working relationship with Winsmith and other potential manufacturers. We will also complete the drive survey initiated in FY98.

Heliostat Issues and Analysis

We will develop an understanding of the fundamental barriers to the production of low-cost heliostats. Benefits will be a more realistic expectation of the cost of energy from CSP systems and realistic estimates of the potential benefits of advanced reflectors.

Dish Conversion

The objective of this task is to develop advanced receiver and conversion technologies to improve performance, cost, reliability, and commercialization prospects of dish/engine generation systems and to address long-term receiver and engine issues.

STM On-Sun Testing

We will complete on-sun testing of the STM engine with a heat pipe at Sandia, attempting to set a world record for conversion efficiency. The system is enhanced over the SAIC PCU with a Thermacore heat-pipe receiver, demonstrating the performance advantages of the heat pipe and providing valuable integration and controls experience. The testing demonstrates the capability of a heat-pipe receiver in a system environment and increases program visibility.

Wick Development

We will continue developing and testing high-performance felt-wick heat-pipe receivers for dish/Stirling systems, including capsule, bench, and full-scale testing and materials analysis. Successful operation of durable wicks will lead to incorporation of these receivers in commercial systems, substantially improving performance. This project brings heat pipes closer to commercial reality. We have demonstrated 20% improvement in the performance of a Stirling engine with a heat pipe on prototype systems. Our goals are full-scale receiver operation for at least 25 hours without hot spots and completion of 5,000 hours of bench-test operation with the selected configuration. Wick development is supplemented with $183,000 ($61,000 to Sun•Lab) from the Initiatives for Proliferation Prevention Program, in cooperation with two former Soviet laboratories.

We will also develop and evaluate alternative advanced-wick materials for heat-pipe receivers for dish/Stirling systems, including plasma-sprayed wicks and vendor-supplied samples. We will also continue to develop design and evaluation tools. This task provides potentially more robust alternatives to the felt wick, addressing shortfalls of current commercial wick performance capabilities, and also provides much-needed design and quality control tools.

Hybrid Development

The heat-pipe hybrid allows combined gas and solar heat input. It also provides potentially more efficient hybridization than the direct-illumination receiver does. Because most customers require hybridization, we will continue developing a low-cost hybrid heat-pipe receiver targeted to complete favorably against existing diesel generation systems. Our heat-pipe approach emphasizes low cost and incorporates co-firing (simultaneous solar and gas) operation. We will complete the tests of the bench-scale receiver, the design of the full-scale receiver, and fabrication of full-scale prototype receiver including controls and laboratory support equipment. The full-scale receiver will be used in future tests to demonstrate the design, validate design codes, and provide a test bed for further design refinement.

We will modify the bench-scale test rig to support STM-supplied burner assembly testing or other alternate burner assemblies to reduce cost or extend life.

Ft. Huachuca

We will continue to support demonstration testing of the Ft. Huachuca dish/Stirling system, including test support and data analysis. As a result, we will gain systems-level experience with a commercial kinematic Stirling engine. Experience is valuable for the Sun•Lab remote power system using the same engine. Our goals are 500 additional on-sun hours and continuous progress averaging 40 hours per month.

Long-term Research and Development

Investigation of novel designs for future development is a modest budget item, but is a strategically important aspect of this task. These designs provide the creative foundation for future innovation that may lead to breakthroughs for CSP technology. In this activity, we will investigate advanced concepts at the feasibility analysis and proof-of-principal level. One area of research is the energy conversion device, for which we will investigate advanced concepts that can reduce costs and improve reliability. These devices could eventually replace the engine in distributed power applications. Another example of research in this area is volumetric receiver designs, which are capable of high temperature, high efficiency, and interfacing with advanced heat engines and combined cycles. We will also investigate new system designs, such as high-temperature power towers driving modular combined cycles.

Solar Thermoacoustic Converter

We will develop and evaluate the Clever Fellows Initiative Consortium optically heated thermoacoustic converter for small, remote-power applications. We will demonstrate and evaluate the on-sun operational performance of a 1-kW thermoacoustic engine. Solar thermoacoustic converters are a new and potentially efficient, cost-effective, and reliable engine option for small-scale (1 to 2 kW) applications.

Edtek Thermophotovoltaic Generator

We will conduct an on-sun demonstration of the Edtek thermophotovoltaic generator. This generator is a potentially efficient and low-cost means of generating CSP electricity without moving parts.

CSAR Solicitations

We will solicit Sun•Lab staff for new projects and award at least one new internal Concentrating Solar Advanced Research (CSAR) project. CSAR projects provide the program with new concepts that could lead to radically improved performance and cost.

Facilities

In support of the Concentrating Solar Power Program's objectives, we will operate and maintain Sandia's NSTTF and NREL's High-Flux Solar Furnace (HFSF).

Facilities Operation and Maintenance

We will operate and maintain high-quality test facilities to provide high-flux/high-temperature testing and evaluation capabilities. We will ensure these facilities are in compliance with environment, health, and safety requirements.

Facilities Support

Facilities overhead pays for NSTTF utilities and corporate-supported operations and maintenance. It also provides the required space for the test facilities at Sandia.

Major Milestones – Path 3: Advanced Components and Systems		
Milestone Description	**Staff Responsible**	**Expected Completion**
Complete STM on-sun testing with the Thermacore heat-pipe receiver and calculate peak performance.	C. Andraka	Dec 98
Complete a detailed design review of the full-scale hybrid heat-pipe receiver.	J. Moreno, M. Mehos	Mar 99
Begin on-sun testing of a next-generation felt-wick heat-pipe receiver.	C. Andraka	Mar 99
Document accelerated exposure testing for advanced commercial laminate mirror.	G. Jorgensen	Apr 99
Fabricate three candidate advanced solar mirror designs.	G. Jorgensen	Jul 99
Complete on-sun tests of an advanced converter (thermophotovoltaic or thermoacoustic) at the HFSF.	A. Lewandowski	Aug 99
Complete accelerated exposure testing of advanced reflector materials.	G. Jorgensen	Sep 99
Complete 500 additional on-sun hours on the Ft. Huachuca dish/Stirling system.	R. Diver	Sep 99
Complete 5,000 hours of testing on a bench-scale durability prototype heat pipe simulating the selected full-scale approach.	C. Andraka	Sep 99
Complete fabrication of a full-scale hybrid heat-pipe receiver.	J. Moreno, M. Mehos	Sep 99

PATH 4: STRATEGIC ALLIANCES AND MARKET AWARENESS

The objective of this path is to expand alliances with stakeholders who are developing and implementing CSP technologies. Strong alliances with stakeholders are necessary for defining technology, markets, and application requirements for CSP technologies. These alliances will support our industry interactions and ensure effective research and development focus and technology transfer.

Technology Roadmapping

In this task, we will work collaboratively with industry, end users, and key stakeholders to update our technology development roadmaps. Technology roadmaps are a specific type of planning activity that use market requirements to define specific technical goals and development activities necessary to achieve market success. Technology roadmaps are specific to both the market application and the technology (e.g., troughs, power towers, or dish/engine systems).

Technology Roadmap Documentation and Follow-up

We will complete roadmap workshop documentation and develop a roadmap for each technology. We will generate web versions of these documents to go on the Sun•Lab web site. We will provide details to the CSP Five-Year Plan and information to focus and prioritize activities for Annual Operating Plan planning. We will help unify the industry voice and leverage the capabilities of industry and Sun•Lab. We will use the technology roadmaps to make decisions in the DOE/Sun•Lab and industry planning and budgeting processes.

Market Requirements

Characterization of market requirements will be an important activity to ensure that viable technology options are being provided to our partners. The current activity used to evaluate alliances and markets for CSP technologies will be developed into a long-term activity to determine directions for the Concentrating Solar Power Program, and this information will be integrated into the technology roadmapping efforts. Resource assessment will continue to be a key part of understanding where the CSP technologies can be cost effective and to help potential users understand the magnitude of the renewable resource that is available to them. We will also conduct specific application assessment studies (such as village power requirements), as requested.

Thunderball II

We will continue outreach to key stakeholders (states, utilities, independent power producers, industry, and financial institutions). We will also continue to improve our understanding of the market and to work to promote CSP technologies.

Mexico Study

We will support industry assessment of an initial CSP project in Mexico, including evaluation of technology and funding options.

Market Development

We will provide technical support to stakeholders in developing and evaluating the emergence of green markets and international opportunities. This technical support will involve understanding the drivers for green markets and their effect on states, power producers, and the CSP industry. Our specific activities will include supporting DOE and the states in implementing green markets through their participation in the decision-making process. The potential for international opportunities with CSP systems is very large, and we will continue our involvement in the International Energy Agency/Solar Power and Chemical Energy Systems (IEA/SolarPACES) Program to keep abreast of international technology developments.

Eskom Technical Assistance

We will provide technical support to Eskom in conducting a prefeasibility study for deployment of dispatchable CSP in South Africa. This study could result in construction of a commercial plant using Global Environment Facility (GEF) funds, creating opportunities for U.S. industry and worldwide visibility for the technology.

START Missions

We will provide technical support to SolarPACES Solar Thermal Analysis, Review, and Training (START) Missions in anticipation of generating successful GEF funding application. This support will encourage international interest in CSP technologies and could lead to additional collaborative opportunities.

China Reverse Trade Mission

We will bring Chinese decision makers to the United States to familiarize them with CSP technology and move toward a GEF-supported project. A region near Lhasa, Tibet, offers good near-term opportunity for a project within China.

Communications

The major objective for the Sun•Lab Communications team is to create effective communication products for the Concentrating Solar Power Program. 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 program. The team includes industry partners as appropriate in creating these materials.

Management Communications

We will produce the Annual Operating Plan, quarterly reports, annual summary report, and exhibits, which are an integral part of our current business approach.

General Outreach/Web Site

Web information is becoming more important for general outreach and communication. As a result, we will support general program communications; maintain our web site; maintain our public relations thrust for new directions of the Concentrating Solar Power Program; and prepare one to two new fact sheets, exhibits, and materials for the Sun•Lab web site.

Major Milestones – Path 4: Strategic Alliances and Market Awareness

Milestone Description	Staff Responsible	Expected Completion
Complete detailed plans for the Chinese Reverse Trade Mission visits.	M. Hale	Jan 99
Complete the final trough roadmap.	H. Price	Feb 99
Complete the draft dish roadmap.	H. Price	Apr 99
Complete the draft tower roadmap.	H. Reilly	Apr 99
Receive Eskom's decision on proceeding with the prefeasibility study.	T. Williams	May 99
Produce two new fact sheets.	A. Van Arsdall	Sep 99

FY99 MAJOR MILESTONE SUMMARY – LISTED BY COMPLETION DATE			
Path	**Milestone Description**	**Staff Responsible**	**Expected Completion**
Advanced Components and Systems	Complete STM on-sun testing with the Thermacore heat-pipe receiver and calculate peak performance.	C. Andraka	Dec 98
Dispatchable Power	Complete Solar Two plant parasitic tests.	G. Kolb	Jan 99
Strategic Alliances and Market Awareness	Complete detailed plans for the Chinese Reverse Trade Mission visits.	M. Hale	Jan 99
Distributed Power	Place Phase 2X contract with SAIC.	T. Mancini	Feb 99
Strategic Alliances and Market Awareness	Complete the final trough roadmap.	H. Price	Feb 99
Distributed Power	Install two USJVP systems in Phoenix.	T. Mancini	Mar 99
Dispatchable Power	Complete optical testing of SAIC's heliostat and produce draft report.	J. Grossman	Mar 99
Advanced Components and Systems	Complete a detailed design review of the full-scale hybrid heat-pipe receiver.	J. Moreno, M. Mehos	Mar 99
Advanced Components and Systems	Complete on-sun testing of a felt-wick heat-pipe receiver.	C. Andraka	Mar 99
Dispatchable Power	Complete critical testing at Solar Two.	J. Pacheco	Apr 99
Advanced Components and Systems	Document accelerated exposure testing for advanced commercial laminate mirror.	G. Jorgensen	Apr 99
Strategic Alliances and Market Awareness	Complete the draft dish roadmap.	H. Price	Apr 99
Strategic Alliances and Market Awareness	Complete the draft tower roadmap.	H. Reilly	Apr 99
Dispatchable Power	Award USA Trough Phase 1 contract.	H. Price	May 99
Strategic Alliances and Market Awareness	Receive Eskom's decision on proceeding with the prefeasibility study.	T. Williams	May 99

FY99 MAJOR MILESTONE SUMMARY – LISTED BY COMPLETION DATE			
Path	**Milestone Description**	**Staff Responsible**	**Expected Completion**
Dispatchable Power	Complete Solar Two plant performance evaluation.	J. Pacheco	Jun 99
Distributed Power	Place Phase 2 of Boeing DECC contract.	R. Diver	Jul 99
Dispatchable Power	Extend USA Trough Phase 2 contract.	H. Price	Jul 99
Advanced Components and Systems	Fabricate three candidate advanced solar mirror designs.	G. Jorgensen	Jul 99
Advanced Components and Systems	Complete on-sun tests of an advanced converter (thermophotovoltaic or thermoacoustic) at the HFSF.	A. Lewandowski	Aug 99
Distributed Power	Complete 1,500 total hours on two systems.	T. Mancini	Sep 99
Distributed Power	Complete testing of a fully integrated 10-kW dish/Stirling system in grid-connected mode at the NSTTF.	J. Muir	Sep 99
Dispatchable Power	Test heliostat adaptive tracking algorithm.	S. Jones	Sep 99
Dispatchable Power	Document Solar Two test and evaluation activities.	J. Pacheco	Sep 99
Dispatchable Power	Complete LS-3 collector performance test.	R. Mahoney	Sep 99
Dispatchable Power	Apply Black Crystal absorber coating to heat-collection elements.	R. Mahoney	Sep 99
Advanced Components and Systems	Complete accelerated exposure testing of advanced reflector materials.	G. Jorgensen	Sep 99
Advanced Components and Systems	Complete 500 additional on-sun hours on the Ft. Huachuca dish/Stirling system.	R. Diver	Sep 99
Advanced Components and Systems	Complete 5,000 hours of testing on a bench-scale durability prototype heat pipe simulating the selected full-scale approach.	C. Andraka	Sep 99
Advanced Components and Systems	Complete fabrication of a full-scale hybrid heat-pipe receiver.	C. Andraka	Sep 99
Strategic Alliances and Market Awareness	Produce two new fact sheets.	A. Van Arsdall	Sep 99
Dispatchable Power	Complete hot-salt pump testing.	J. Pacheco	Oct 99

DOE Concentrating Solar Power Program

FY99 Budget Planning	Sandia			NREL			DOE		Total		
AOP Final 1/15/99	FTE$	Contr	Total	FTE$	Contr	Total	Org	Total	FTE$	Contr	Total
Concentrating Solar Power Total	**4207**	**6071**	**10278**	**1634**	**1388**	**3022**		**3700**	**5841**	**11159**	**17000**
Path 1. Distributed Power	**855**	**3760**	**4615**	**417**	**47**	**464**		**0**	**1272**	**3807**	**5079**
USJVP Activities	95	2118	2213	55	10	65		0	150	2128	2278
DECC Activities	125	820	945	0	0	0		0	125	820	945
Reliability Improvement	185	32	217	262	37	299		0	447	69	516
Cost Reduction/SolMaT	0	0	0	0	0	0		0	0	0	0
Remote Power Systems	450	790	1240	100	0	100		0	550	790	1340
Path 2. Dispatchable Power	**1530**	**626**	**2156**	**227**	**620**	**847**		**3000**	**1757**	**4246**	**6003**
Solar Two	1072	351	1423	142	15	157	GO	3000	1214	3366	4583
Power Tower Technology	213	170	383	0	0	0		0	213	170	383
Trough Technology	195	85	280	85	605	690		0	280	690	970
Cost Reduction/SolMaT	50	20	70	0	0	0		0	50	20	70
Path 3. Adv Components/Systems	**1552**	**1557**	**3109**	**830**	**599**	**1429**		**0**	**2382**	**2156**	**4538**
Systems Analysis	100	0	100	50	0	50		0	150	0	150
Concentrators	255	125	380	485	265	750		0	740	390	1130
Dish Conversion	902	538	1440	100	119	219		0	1002	657	1659
High Efficiency Systems	0	0	0	0	0	0		0	0	0	0
Long-term R&D	50	0	50	145	190	335		0	195	190	385
Facilities	245	894	1139	50	25	75		0	295	919	1214
Path 4. Strat Alliances/Market Awareness	**270**	**128**	**398**	**160**	**122**	**282**		**0**	**430**	**250**	**680**
Technology Roadmapping	80	10	90	40	10	50		0	120	20	140
Market Requirements	15	10	25	35	60	95		0	50	70	120
Market Development	95	18	113	50	42	92		0	145	60	205
Communications	80	90	170	35	10	45		0	115	100	215
HQ Holdback	**0**	**0**	**0**	**0**	**0**	**0**	**HQ**	**700**	**0**	**700**	**700**

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