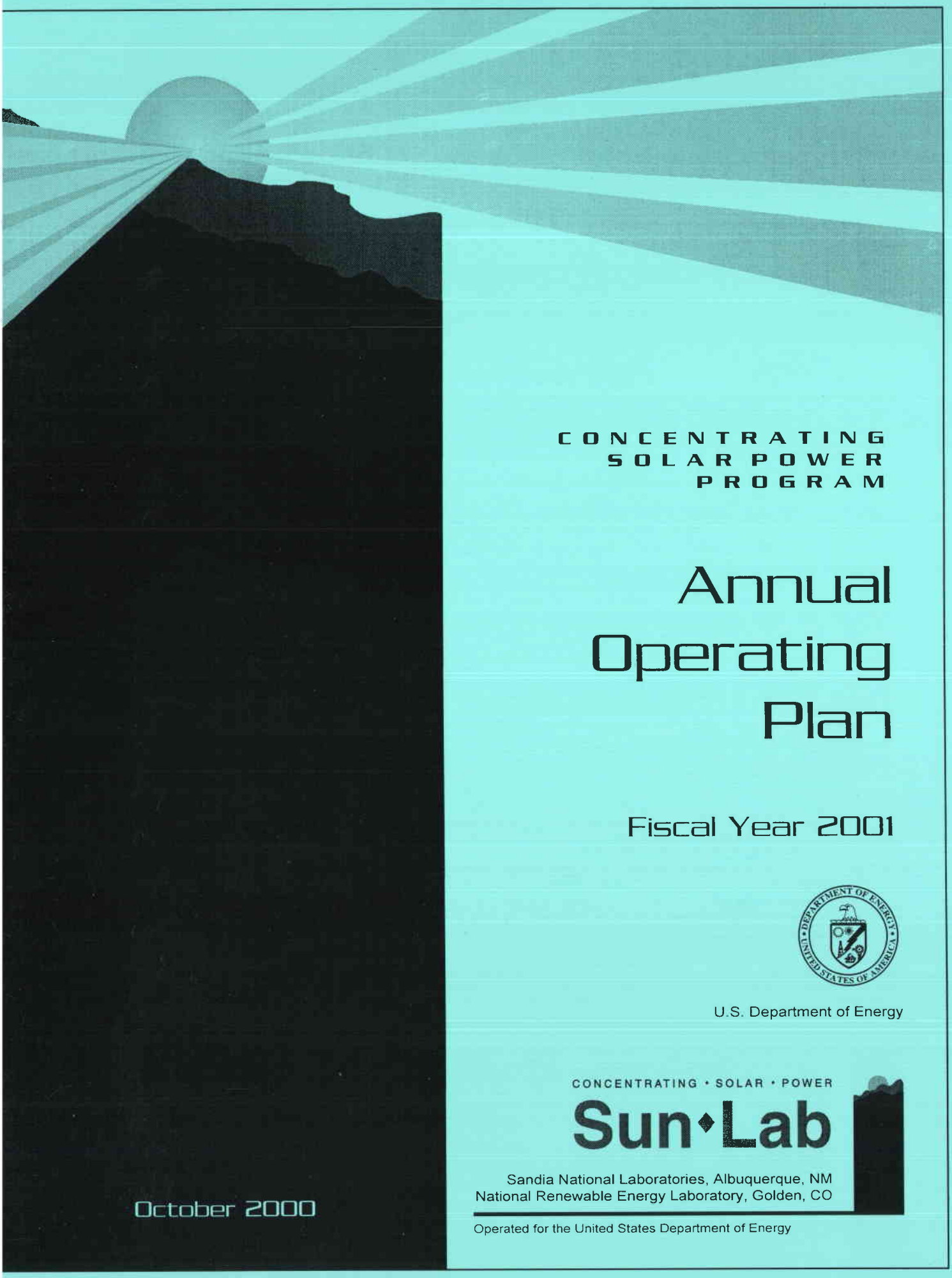

CONCENTRATING
SOLAR POWER
PROGRAM

Annual Operating Plan

Fiscal Year 2001

U.S. Department of Energy

CONCENTRATING • SOLAR • POWER

Sun•Lab

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

Operated for the United States Department of Energy

October 2000

Foreword

This Annual Operating Plan documents the activities of the Department of Energy and its national laboratories (Sandia National Laboratories and the National Renewable Energy Laboratory, working together as SunLab) in their support of DOE's Concentrating Solar Power (CSP) Program. Activities and budgets were developed in cooperation with the U. S. CSP industry (who refer to themselves collectively as CSP Inc) to best achieve the goals of the program, the technology, and CSP Inc. In an effort to reduce overhead costs, this year's Annual Operating Plan was developed on a web-based system. This printed version simply provides an archival copy of the on-line version.

Approved:

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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 (cooperating as CSP Inc) 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 three paths:

- Developing and demonstrating high-reliability distributed power systems;
- Reducing costs of dispatchable solar power; and
- Developing advanced components and systems.

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 also will achieve energy costs suitable for entry into high value markets within about five years.
- Address the highest priority activities required to bring commercially proven trough and demonstrated power tower technologies to early dispatchable power markets. Accompanied by early demonstrations supported by both green power markets, both in the U. S. and abroad, 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 costs competitive in high-value peaking markets within the next few years.
- 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 vision of 20 GW by 2020.
- Keep our technology efforts focused on the most critical needs of industry (through close cooperation with CSP Inc); ensure a technology capable of meeting market requirements; and support domestic and international information flow and policy decisions favorable to renewable energy.

Milestones/Metrics

Individual activity milestones and metrics for our program are listed with each activity. Program milestones and metrics (those by which the overall program is evaluated) are indicated with the word "key". Others are specific to the individual teams' evaluations.

CSP Industry Measures of Success for FY01

In addition to the program milestones described above, the CSP industry in the U. S. (who refer to themselves collectively as CSP, Inc) has committed to the following Measures of Success for FY01. Our program, as outlined in this AOP, supports these efforts, although overall responsibility for these measures rests with the individual industry partners.

Dishes

SAIC/STM O&M and engineering development	Demonstrate 90% availability on Golden system (SAIC)
Boeing/SES DECC Phase II	Install and operate new or refurbished system(s) (SES)
Nevada Project startup support	Identify site and install 1 or more dish(es) (complete systems by 12/01) (SAIC, SES, WGA, CTEC)
Advanced dish development system	Install and operate visible and reliable Indian 10-kW demo (WGA)

Troughs

USA Trough, receiver, and concentrator development	Close firm project for 30-50MW trough system in U.S. or international GEF project as solar field integrator (Duke Solar)
Trough Storage	Successfully complete pilot-scale demonstration of first-generation technology (Sun• Lab)

Towers

Technical support to Solar Tres	Complete funding and reach financial closure on Solar Tres project and commence full engineering and design (Nexant)

Small Systems

Small dishes / CPV	Install and reliably operate a 2kWe CPV off-grid system at NREL test site (CTEK) Install and operate 25 2-kW grid-connected dishes at APS (privately funded) (CTEK) Demonstrate 40% solar-to-electricity efficiency (world record) at 100 suns or greater (United Innovations)
Modular trough systems	Close firm distributed generation project (up to 100kW) in U.S. Southwest (Duke Solar) Install 6kW ORC at NC demo site (Duke Solar) Install 100kW engine at Carrier plant in Brazil (Duke Solar)

Image

Program Communications	Define new image and provide first materials (Roadmap draft (3/01), States meeting (5/01), polished 4-page CSP framework (7/01))
Special Studies	Complete two studies refuting NRC (ADL, Morse)

Concentrating Solar Power Program

FY01 AOP Budget

		Sandia				NREL				DOE	CSP			
		FTE$	Pur-chases	R&D Contr	Total	FTE$	Pur-chases	R&D Contr	Total	Total	FTE$	Pur-chases	R&D Contr	Total
CSP Total	WBS	3150	1330	2600	7080	1680	240	3324	5244	1476	4830	1570	7400	13800
Path 1. Distributed Power		1133	363	2471	3967	687	80	2541	3308	370	1820	443	5382	7645
Grid Reliability Systems	1.1	260	54	1658	1972	164	10	1950	2124	200	424	64	3808	4296
Remote Power Systems	1.2	689	305	793	1787	0	0	0	0	0	689	305	793	1787
Reliability Improvement	1.3	94	4	0	98	90	4	0	94	0	184	8	0	192
Diversified Small Systems	1.4	90	0	20	110	433	66	591	1090	170	523	66	781	1370
Path 2. Dispatchable Power		1379	525	30	1934	498	80	645	1223	456	1877	605	1131	3613
Advanced Dev & Systems Testing	2.1	509	240	30	779	348	45	550	943	426	857	285	1006	2148
Storage and Hybridization	2.2	180	136	0	316	120	20	50	190	30	300	156	80	536
Tech Support to Industry Projects	2.3	690	149	0	839	30	15	45	90	0	720	164	45	929
Path 3. Adv Component Research		638	442	99	1179	495	80	138	713	50	1133	522	287	1942
System Analysis	3.1	41	38	24	103	115	0	0	115	0	156	38	24	218
Facilities	3.2	225	305	0	530	30	17	0	47	0	255	322	0	577
Optical Materials	3.3	97	7	0	104	340	43	138	521	0	437	50	138	625
Communications	3.4	275	92	75	442	10	20	0	30	50	285	112	125	522
HQ Holdback		0	0	0	0	0	0	0	0	600	0	0	600	600
Congressional	H.1	0	0	0	0	0	0	0	0	250	0	0	250	250
EE/OPT Collaboration	H.2	0	0	0	0	0	0	0	0	350	0	0	350	350

FY01 AOP Input Summary

Guidance **View all Activities in Detail**

Add New Activity

(Team leaders should determine WBS numbers and assure no duplication.)

Display Activities ranging from Priority 1 - 4 Submit

WBS	Title	Priority	SNL FTE	NREL FTE	FTE$	Purch	R&D	Total	C/O
Path 1: Distributed Power			4.36	2.99	1820	443	5382	7645	0
1.1.1	SAIC/STM O&M and Engineering Development	1	.39	.71	264	24	2008	2296	0
1.1.2	Boeing/SES DECC: Phase 2	1	.46	.00	120	40	1600	1760	0
1.1.3	Nevada Project Planning	4	.15	.00	40	0	200	240	0
1.2.1	Advanced Dish Development System	1	2.25	.00	584	230	708	1522	0
1.2.2	Indian liason and training	3	.40	.00	105	75	85	265	0
1.3.1	Reliability Improvement	1	.36	.39	184	8	0	192	0
1.4.1	Small Dish Systems	4	.00	1.27	293	36	261	590	0
1.4.2	CPV Technical Issues	4	.00	.31	70	10	100	180	0
1.4.3	Modular Trough Systems	4	.15	.31	110	20	230	360	0
1.4.4	University Activities	4	.00	.00	0	0	170	170	0
1.4.5	Microturbine Solar Dish Feasibility	4	.19	.00	50	0	20	70	0
Path 2: Dispatchable Power			5.31	2.17	1877	579	1157	3613	0
2.1.1	Trough Receiver Development	1	1.21	.00	314	165	271	750	0
2.1.2	Near-Term Trough Concentrator	3	.75	.17	235	80	185	500	0
2.1.3	USA Trough Phase II	1	.00	1.34	308	40	550	898	0
2.2.1	Thermocline Storage System	1	.50	.00	130	100	26	256	0
2.2.2	Advanced Thermal Storage Fluid	3	.19	.52	170	30	80	280	0
2.3.1	Trough Technical Support	4	.15	.13	70	15	45	130	0
2.3.2	Technical Support to Solar Tres	1	2.50	.00	650	149	0	799	0

Path 3: Advanced Components and Systems			2.46	2.16	1133	522	287	1942	0
3.1.1	General Systems Support	1	.16	.07	56	38	24	118	0
3.1.2	Resource Assessment	1	.00	.44	100	0	0	100	0
3.2.1	Facilities O&M	1	.87	.13	255	322	0	577	0
3.3.1	Optical Testing	1	.00	.57	130	33	0	163	0
3.3.2	Fundamental Analysis	1	.37	.44	197	14	0	211	0
3.3.3	Outdoor Testing	2	.00	.26	60	0	0	60	0
3.3.4	Screen New/Advanced Materials	2	.00	.22	50	3	138	191	0
3.4.1	CSP Program Communications	1	.67	.00	175	82	0	257	0
3.4.2	Special Studies	1	.23	.00	60	0	125	185	0
3.4.3	SolarPACES Support	1	.15	.04	50	30	0	80	0
Path 4: Other			.00	.00	0	0	600	600	0
4.1	HQ Holdback - Congressional	1	.00	.00	0	0	250	250	0
4.2	HQ Holdback - EE/OPT Collaboration	1	.00	.00	0	0	350	350	0

FY01 Annual Operating Plan

Brief Title: SAIC/STM O&M and Engineering Development
Activity Title: SAIC/STM O&M and Engineering Development
WBS Number: 1.1.1 **Staff:** Mehos, NREL
Path: Distributed Power **Priority:** 1
Primary Activity: SAIC O&M and Engineering Development

Background: In FY00, NREL let a two-phase subcontract to SAIC/STM with the following objectives:
- Achieve 200 hours of autonomous operation for each system without incident
- Achieve 90% system availability for all three systems (70% for a single system by mid-year), and
- Collect reliability and O&M cost and performance data for input to SunLab dish/engine reliability database.

As of the end of July, SAIC has achieved 2187 hours of on-sun solar operation on all three; achieved hybrid operation on all three systems (25 kW demonstrated on APS West); demonstrated low emissions while operating on hybrid; and improved availability over prior years

Objectives: FY01 Objectives
- Achieve 90% system availability (as measured over a single, continous four-week period) for a solar-only Golden-based system
- If successful (90% availability of Golden-based system), install one solar-only system in Nevada
- Continue O&M of the SRP-based hybrid dish/Stirling system
- Collect high-quality reliability, O&M cost, and performance data for input to the SunLab web-based dish/converter reliability database

Approach: While meeting the mid-year objective of 70% availability for a single system, SAIC was unable to meet the end-of-year objective of 90% availability for all three systems. Therefore a revised approach has been developed for FY01. Key aspects of the revised approach are to: 1) curtail the current scope of operations of SAIC/STM demonstration projects with the objective of reducing program costs and focusing O&M and engineering activities and 2) negotiate a limited (five month) extension of the existing subcontract with SAIC with a focused effort on improving the reliability of a Golden-based solar-only system and 3) if successful, incrementally fund the installation of a solar-only dish/Stirling system at a site in Nevada. The Nevada activity is dependent upon the budget allocated for the Nevada project, site and participant selection process and other factors that may fall outside of the scope of the subcontract. This effort will focus on operating and maintaining the existing SAIC-installed systems located in Arizona and Colorado. In addition to the baseline O&M activity, SAIC will implement engineering modifications to the current system design with the objective of eliminating the highest frequency failures documented in FY00. As in FY00, performance and reliability data generated from the systems will be compiled weekly and for inclusion in the SunLab web-based dish/engine reliability database. Lastly, SAIC will

design, fabricate, and test advanced components with the goal of increasing reliability and performance or reducing the installed cost of the current design.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.385	0.7131		1
FTE $	100	164		264
Purchase $	14	10		24
R&D Contract $	0	2008	0	2008
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	2296

Milestones

MS	Milestone	Staff	Due Date
d	Complete installation of SAIC dish at Nevada Test Site	Mehos	06/2001
a	Issue RFP for FY01 activities	Mehos	11/2000
b	Award subcontract for SAIC O&M and engineering development	Mehos	01/2001
c	Achieve 90% availability of Golden-based solar-only dish/Stirling system	Mehos	05/2001

Return to Summary Table

Brief Title: Boeing/SES DECC: Phase 2

Activity Title: Boeing Dish Engine Critical Components Project, Phase 2

WBS Number: 1.1.2 **Staff:** Mancini, Sandia

Path: Distributed Power **Priority:** 1

Primary Activity: DECC Activities

Background: Phase 1 of the SES/Boeing DECC Project started in March of 1998 and was completed in July of 1999. In Phase 1, Boeing and SES reassembled one McDonnell Douglas dish Stirling system and tested a second engine at Kockums in Sweden. In Phase 1, Boeing/SES achieved 3134 hours of on sun operation and generated 42,042 kWhrs of solar power, 4500 hours of operation on the test cell engine, and 23.5 kW of peak power output.

Under a letter contract for Phase 2 placed by Sandia for $140K, SES continued to invest in engine parts and tooling. Boeing/SES installed and started to operate 2nd dish/engine system. Boeing/SES continued testing under the letter contract, achieving an additional 3568 hrs. of solar operation, 48,078 kWhrs of power generation, 3702 hrs - test cell operation, and 24.3 kW Peak on both systems through Oct. of 2000.

At the completion of Phase 1 in Oct. of 1999, the contract was assigned to NREL. In Oct. of 2000, it was assigned back to Sandia. Negotiations to place the Phase 2 contract began immediately.

Objectives: Phase I: Establish the viability of Mark IV 495 PCU; collect on-sun, operating data for engine/receiver; establish the O&M and reliability of PCU; develop commercialization plans for the system
Phase 2: Fully integrate updated dish/PCU system; develop an operational data base for the dish/Stirling system; start to implement a commercialization plan
Phase 3: Deploy a number of Dish Stirling systems at Customer sites (Nevada is current focus); Further develop system operational data base; Establish credibility of system (performance, life, O&M, cost, etc.)

Approach: Phase 2 activities will include upgrading 3 and building 5 new engines; redesigning the PCU; upgrading the dish design; developing new dish and PCU controls; installing 6 more systems, including 2 of totally new design; and operating 8 systems as a mini-IPP in California.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.462	0.0		0
FTE $	120	0		120
Purchase $	40	0		40
R&D Contract $	0	1600	0	1600
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	1760

Milestones

MS	Milestone	Staff	Due Date
a	Place Phase 2 DECC Contract (KEY)	Mancini	01/2001
b	PCU Operational with New Components	Mancini	02/2001
c	First 24-hour Test Cell Operation	Mancini	06/2001
e	Start Testing New PCU (KEY)	Mancini	08/2001
d	Delivery of system to Nevada for Testing	Mancini	06/2001

Return to Summary Table

Brief Title: Nevada Project Planning
Activity Title: Demonstration of Dish/Stirling Systems at UNLV
WBS Number: 1.1.3 **Staff:** Mancini, Sandia
Path: Distributed Power **Priority:** 4
Primary Activity: Other Path 1
Background: This project is the start of Phase 3 of both the USJV and DECC Projects; i.e., the start of deployment of systems in the field. The initial field

demonstration requires limited deployment and careful monitoring of the systems. The UNLV university environment provides the opportunity for careful oversight of the systems with the potential to expand deployment into an operational field in the nearby Eldorado Valley.

Objectives: Project objectives: a) demonstrate field operation of several different types of dish/Stirling systems; b) achieve high-visibility for d/s systems; and c) develop a base of trained O&M personnel

Approach: This approach involves placing a contract with UNLV to develop a test site for dish/Stirling systems. Our plan is to deploy three different dish/Stirling systems, initially in limited numbers, at a test site on the UNLV campus. As part of ongoing activities at the University, undergraduate and graduate students will be trained and used to provide daily operation and maintenance of the systems. In so doing, we will be developing a base of trained professionals who could be utilized in future deployments of these systems.

It is our understanding that, due to limited space, it is unlikely that a large deployment of systems can be achieved on campus. Consequently, it will be important to identify a site and potential independent power producer partners to work with to deploy larger numbers of systems. The most likely target for this site is in the nearby Eldorado Valley where a gas-turbine plant is being installed.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.154	0.0		0
FTE $	40	0		40
Purchase $	0	0		0
R&D Contract $	0	0	200	200
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	240

Milestones

MS	Milestone	Staff	Due Date
a	Develop a MOU between UNLV and dish/Stirling system providers	Mancini	02/2001
b	Select and dedicate a test site on UNLV Campus	Mancini	06/2001

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Brief Title: Advanced Dish Development System
Activity Title: Advanced Dish Development System
WBS Number: 1.2.1

Staff: Diver, Sandia

Path: Distributed Power **Priority: 1**

Primary Activity: Other Path 1

Background: The overall objective of the CSP program is to develop and validate concentrating solar power technologies that meet the needs of the marketplace. The current CSP emphasis on distributed power applications, which includes dish/engine technologies, is to develop systems that can operate reliably for loads ranging from a couple of kilowatts to several megawatts. Many applications are for remote power (such as water pumping and village electrification) where there is no utility grid. In these applications, diesel engine generators are the primary competition to CSP technologies. Key market criteria for CSP entry into distributed power applications are reliable unattended operation, minimal (and low technology) service requirements, and competition with the cost of alternatives (which are typically quite high).There are several critical issues facing the development of dish/Stirling systems for remote applications. The first is reliability, as measured by availability, Mean Time Between Failure (MTBF), and operation and maintenance (O&M) costs. The second issue is power management. To date, virtually all dish/Stirling systems have been grid-connected. Providing the power, and operational control needed to start, operate and respond to faults requires development. A third issue is cost, although this issue is currently less critical because commercial sales will occur in high-value markets at current costs if reliability and O&M are acceptable. The Advanced Dish Development Project addresses many of the issues cited above. Specific features that are being addressed include: remote, off-grid application; automatic startup and unattended operation; initial on-grid demonstration followed by off-grid development and validation; long-term operation to establish reliability; and the assessment of commercialization issues (e.g., the potential for market penetration and job creation, and economic and environmental benefits). The project involves integration and testing, at a system level, of advanced dish technology to meet the need of the demanding remote power market. Testing includes long-term unattended, automatic operation of stand-alone 9-kWe dish/Stirling solar power generation systems in both on-and off-grid modes at the National Solar Thermal Test Facility (NSTTF) and in the field at a Native American Reservation site. Advanced applications and technology with the potential to help meet the market requirements are incorporated into the test bed and are evaluated in a system context over extended periods of time. Development has focused on extending the application of dish/Stirling systems to water pumping and other single motor applications. The system also incorporates advanced component such as structural facets, heat pipes, and advanced controls and communications.

Objectives: The overall objective of the Advanced Dish Development System project is to develop and validate a 9 kWe dish/Stirling solar power technology that meets the needs of the marketplace. Specifically, the project objective is to develop and field a fully integrated, stand-alone dish/Stirling solar power generation system at a remote, off-grid Native American site in the Southwestern U.S.

Approach: The overall approach involves the design, fabricatation, integration and testing of an advanced dish/Stirling system in automatic, unattended

operation both on-grid and off-grid under representative loads at the NSTTF and at a Native American site in the southwestern U.S. The basic design capitalizes on the proven SOLO 161 Stirling PCU and WGA & Cummins solar concentrator and controls experience. In addition, advanced components are integrated into the test bed with the objective of improving the commercial viability of the system while advancing the state-of-the-art of dish/engine technology. To better understand the market and system requirements the project includes testing at one or more American Indian Applications Partners test sites in the Southwest U.S.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	2.2463	0.0		2
FTE $	584	0		584
Purchase $	230	0		230
R&D Contract $	708	0	0	708
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	1522

Milestones

MS	Milestone	Staff	Due Date
a	Field and demonstrate a prototype stand-alone water pump system at the NSTTF	Diver	03/2001
b	Field a prototype Mod 2 stand-alone or grid-tie system at an Application Partner site (key)	Diver	09/2001
c	Improve system efficiency to over 20% (net) peak	Diver	06/2001

Return to Summary Table

Brief Title: Indian liason and training

Activity Title: Liason and training for the Native American Application Partners in the Advanced Dish Development System project

WBS Number: 1.2.2 **Staff:** Diver, Sandia

Path: Distributed Power **Priority:** 3

Primary Activity: Native American System

Background: As part of the Advanced Dish Development System project, one or more remote power water pumping systems will be fielded on an American Indian reservation in the Southwest U.S. Sandia signed up five Native American Application Partners in FY00. In FY01, Sandia will provide education and training in the operation, maintenance, and repair of the ADDS first generation (Mod 1) prototype. In addition, site visits to the Native American reservations will be conducted to get a better understanding of the system requirements.

Objectives: The objective for FY01 will be to successfully complete training all five Native American tribes at Sandia and to visit most of the potential AP locations. In addition, at least one AP will need to be selected to host the fielded system(s). An objective will be to select the AP for the first system prior to fielding the first Mod 2 prototype so that the AP personnel can assist with the system erection.

Approach: The ADDS team will be involved in AP training and site selection. Training sesions will be 2 to 4 days duration and will be held at Sandia. Individual team members will teach specific training modules in various aspects of the system operation, maintenance and repair. Site selection will involve the SunLab management team and the ADDS team. Selection criteria will include location, technical expertise, cost sharing, and willingness to manufacture and market the system.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.404	0.0		0
FTE $	105	0		105
Purchase $	75	0		75
R&D Contract $	85	0	0	85
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	265

Milestones

MS	Milestone	Staff	Due Date
a	Complete training of prospective Native American Application Partners	Diver	11/2000
b	Place contract with Application Partner for ADDS testing	Diver	04/2001

Return to Summary Table

Brief Title: Reliability Improvement

Activity Title: Reliability Improvement (Database and Methodology Development)

WBS Number: 1.3.1 **Staff: Mehos, NREL**

Path: Distributed Power **Priority: 1**

Primary Activity: Reliability Improvement

Background: A reliability tracking and assessment was initiated in FY00 in order to better understand the reliability of CSP-funded dish/engine systems. The current reliability of dish/engine systems are the major barrier hindering commercial success (dish/engine workshops and A.D. Little study). The activity was undertaken since no standard methodology existed within the CSP program to evaluate reliability of dish/engine systems, and no means existed within the CSP program to independently track the reliability, reliability growth, or performance of CSP-funded dish/engine systems.

In FY00 we were able to complete an initial reliability methodology using Sandia expertise in the area, we negotiated data collection requirements into the SAIC subcontract for O&M and development of three Arizona systems and collected data on the 10K Native American system, completed the 1st phase of web-based reliability database completed, and initiated analysis focusing on the reliability growth associated with the 10K system (this system contains the most complete data set).

Objectives: In FY01, we plan to:
- Resolve issues raised during initial development of web-based system, primarily structure/functionality and speed,
- Update the methodology based on lessons learned in FY00, including a relook at data collection fields and definitions,
Expand the methodology to include data reduction and analysis, and
Develop plans for initiation of a reliability growth activity by working with industry to identify accelerating testing needs and match with SunLab or industry capabilities.

Approach: Over 500 incidents have been inserted into the web-based system for the combined SAIC and Sandia Remote systems. Sufficient data has been collected such that an analysis of current and projected reliability can be statistically assessed with reasonably accurate results. An analysis package will be developed and issued to database users. The package will be written to allow users to download and analyze incident and performance data entered into the database. In parallel, we will continue to update the database software to make it more user friendly and usable for a wider group of users.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.362	0.392		0
FTE $	94	90		184
Purchase $	4	4		8
R&D Contract $	0	0	0	0
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	192

Milestones

MS	Milestone	Staff	Due Date
a	Complete and distribute beta-version of reliability analysis software toolkit for use with web-based database system.	Mehos	1/01
b	Document year-to-date reliability growth of CSP-funded dish/converter systems based on input to reliability database.	Mehos	7/01

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Brief Title: Small Dish Systems

Activity Title: Subcontracts and Industry Support for Small Dish Systems

WBS Number: 1.4.1 **Staff: Mehos, NREL**

Path: Distributed Power **Priority: 4**

Primary Activity: Small Dish Systems

Background: An FY99 market assessment activity focused on identifying applications for remote CSP systems concluded that substantial market opportunities exist for systems with power outputs in the range of 0.5 to 5kWe. In FY00, NREL selected four companies to which to award subcontracts for the development of dish systems and components. SunLab also supported DOE in the selection of three university subcontracts related to small dish systems. SunLab also developed the capability to measure and analyze the performance of small concentrators developed using existing manufacturing methods. This activity, a follow-on to the FY00 work, will focus on supporting the current industry subcontracts by: assessing the performance of systems and components delivered through the subcontracts, supporting broad areas of interest to the industry (i.e. integration of dish structure with a reflector), and supporting specific needs as requested by the industry partners.

Objectives: Objectives for FY01 include the following:
- Assess the performance and reliability of systems and components delivered under four industry subcontracts,
- Continue to assess the optical performance and cost-effectiveness of small-dish concentrators as resources permit,
- Provide support to industry as resources permit.

Approach: Activities will include 1) installation, testing, & assessment of a CTek 2 kW system, 2) delivery, testing and assessment of the STC free-piston Stirling engine, 3) delivery, testing, & assessment of small dish drives and 4) follow-on phase 2 subcontracts with one or more companies based on an assessment of Phase 1 designs. In-house support to industry-led efforts: SunLab will provide an independent assessment of system performance

and reliability of the phase 1 systems or components. Within a limited in-house budget, we will continue our investigation of small dish optical performance and reflector integration since this is an issue of concern which has been raised by ourselves and our industry partners. We will participate and provide input in design reviews for all subcontracts and will collaborate and coordinate as much as possible with CPV development efforts supported by PV and CSP programs.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.0	1.274		1
FTE $	0	293		293
Purchase $	0	36		36
R&D Contract $	0	261	0	261
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	590

Milestones

MS	Milestone	Staff	Due Date
a	Complete initial testing and evaluation of small dish/CPV System (key)	Mehos	8/2001
b	Complete final test report documenting cost and performance of CTek, STC and small drive subcontracts	Mehos	08/2001

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Brief Title: CPV Technical Issues

Activity Title: Flux uniformity, thermal control and CPV receiver development.

WBS Number: 1.4.2 **Staff:** Lewandowski, NREL

Path: Distributed Power **Priority:** 4

Primary Activity: Other Path 1

Background: Flux uniformity and thermal control are two significant technical issues for CPV receivers. Cell module and array performance can be degraded, in the worst case, to the lowest level of flux across the array. It is thus important to minimize flux variations across the module and array surface. Cell performance degrades with increasing temperature and thus minimizing operating temperature will increase system peformance. In FY00, a solicitation to identify and analyze solutions to the flux uniformity problem was issued. Two proposal were selected for funding: Duke Solar and Optical Research Associates. Subcontract results should be available in the first quarter of FY01. These efforts are targeted to two types of solutions. The first is for existing dish designs and will require some type of secondary concentrator to modify the typical Gaussian beam. The second is for either

unique primary shapes or combinations of primary and secondary concentrators that can deliver uniform flux. The development and evaluation of CPV receivers is also an important practical issue. Subcontracts were awarded in FY00 to three companies to develop receiver hardware designs: Amonix for a close-packed array of high efficiency silicon cells; Spectrolab for a close-packed array of multi-junction cells and United Innovations for a unique cavity-based CPV receiver concept. The initial design phase of these efforts will be completed in FY01 and, depending on funding available, one or more will be selected for hardware fabrication and testing. No work on thermal control was funded in FY00.

Objectives: Identify and evaluate various optical concepts to deliver uniform flux for current cells operating at 200-500 suns and for future cells capable of 1000 suns operation. Design, fabricate and test receiver concepts for the next generation of small-scale CPV receivers.

Approach: Evaluate flux uniformity results from FY00 subcontracted efforts and in-house analysis and select the most promising candidate designs for further development. Evalute design results from FY00 subcontracted efforts and select one or more for fabrication and testing at the High-Flux Solar Furnace.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.0	0.305		0
FTE $	0	70		70
Purchase $	0	10		10
R&D Contract $	0	100	0	100
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	180

Milestones

MS	Milestone	Staff	Due Date
a	Complete analysis of flux uniformity concepts and recommend selected concepts for further development.	Lewandowski	03/2001
b	Complete testing of selected CPV receiver concepts.	Lewandowski	07/2001

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Brief Title: Modular Trough Systems
Activity Title: Modular Trough Systems
WBS Number: 1.4.3
Path: Distributed Power
Primary Activity: Other Path 1

Staff: Price, NREL
Priority: 4

Background: CSP trough collectors have been used for nearly 20 years in large central station power plants. ORC air cooled modular power units have been successfully applied for large and small-scale geothermal power plants, with over 600 MW of capacity, during the same period. The merging of these two technologies to produce distributed modular power plants in the 200 kW to 10 MW range offers a new application for both technologies. Although this was demonstrated over 20 years ago, given the advances in technology and the changes in the market, this concept offers an interesting opportunity. The primary advantages of an ORC power cycle for applications with troughs are: - ORCs operate at lower temperatures and trough temperatures can be reduced from 735 to 580F. - This allows use of inexpensive Caloria for a heat transfer fluid in the solar field, in a simple 2-tank thermal storage system to provide heat to operate the ORC at night. - ORCs effectively use air-cooled power cycle with hydrocarbon working fluid and use no water. - ORC power cycles are simple and can be operated remotely without licensed operators. This reduces O&M costs. - CSP Trough technology can be optimized to minimize maintenance and simplify initial installation. At lower operating temperatures these plants are ideal for US supplied non-evacuated receiver tubes. - Modular systems can utilize standardized designs, prefabrication, and minimize on-site erection. Current CSP trough technology is modular in nature and with prefabrication can minimize on-site construction. - With the addition of low cost thermal storage the distributed power system can supply electricity, in modules which may be expanded, at costs competitive with diesel gen-sets. There are a number of potential concerns with small modular solar plants. These include the potential for the O&M costs to be very high, and the lifetime and performanc of ORC systems. In general there is currently significant interest from the emerging US trough industry and US power industry in the modular trough concept. A quote from the power industry "The technology is there, we just need a project!"

Objectives: The overall objective of this effort is the initiation of a modular trough power plant demonstration project in FY02.

FY01 activities have been designed to help achieve this longer term objective. FY01 objectives will include a critical assessment of the modular trough power plants to validate the potential merit of the concept, addressing technical issues key to the success of the concept (such as ORC working fluid stability), initiation of an RFP for a demonstration project next year, assessment and testing of potential working fluids, and a prefeasibility study for modular trough demonstrations.

Approach: SunLab will work with the power industry to complete a pre-feasibility assessment of modular trough power plant technology. The assessment will evaluate the cost, performance, operability, maintenance and lifetime of small systems and develop an improved estimate of power cycle, thermal storage, HTF system, and solar field cost and performance. In addition, SunLab will work with industry to develop optimized power cycles for use in a trough solar application. Evaluate trade-off between efficiency and complexity (simple, mixed fluid, cascade, Kalina, steam). SunLab will work with the Industry to identify the ideal candidate fluids for working at the higher operating temperatures required by solar plants. Once identified, the most promising ORC fluids will be tested to determine their long-term

stability. The project demonstration RFP will be patterned after the recent biomass small system and Geo-Powering the West RFP's. The approach will integrate with the CEC to allow demonstrations that allow access to CEC PIER funds. Phase I is a feasibility study (80/20 cost share) and will be conducted during FY01. Phase II will be a detailed design and cost estimate of a demonstration project(50/50 cost share). Phase III will be include construction and a 3-year operation and testing phase (50/50 cost share). If funding allows, multiple awards may be considered. The contracts will allow for down select at the end of each phase should the project no longer make sense.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.154	0.305		0
FTE $	40	70		110
Purchase $	0	20		20
R&D Contract $	0	230	0	230
Carry Over $	0	0	0	0
		Total (FTE+Purchases+R&D)		360

Milestones

MS	Milestone	Staff	Due Date
a	Complete Modular Trough Power Plant Feasibility Study (key)	Price	09/2001

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Brief Title: University Activities

Activity Title: University Research for the Advancement of Solar Dish/Converter Technology

WBS Number: 1.4.4 **Staff: Other,**

Path: Distributed Power **Priority: 4**

Primary Activity: Other Path 1

Background: A goal of DOE's Concentrating Solar Power (CSP) Program is the development of clean, competitive, and reliable power options using concentrated sunlight. To achieve this goal, the Department of Energy is interested in fundamental research that will advance existing solar dish/converter technology through improved performance, increased reliability, and reduced cost. The DOE is also interested in supporting research of new and innovative system concepts, which have the potential for efficiently converting concentrated solar energy to electricity in the 1 to 5 kWe range. In March 2000, the Office of Concentrating Solar Power, through the Golden Field Office, issued a solicitation entitled University Research for the Advancement of Solar Dish/Converter Technology. Under

the solicitation, innovative subsystem, component, or system concepts were sought for ultimate integration into a technically and economically viable dish/converter system in the 1 to 5 kWe range. As a result of the solicitation, Cleveland State University and Drexel University were awarded multi-year cooperative agreements. Cleveland State University, in cooperation with the University of Minnesota, NASA Glenn Research Center, and Gedeon Associates, will be researching performance improvements of the Stirling converter. The research focuses on regenerator redesign through experiments, computations and modern fabrication techniques. The three-year cooperative agreement to Cleveland State University is value at $663,715 with DOE contributing $541,000. As a result of the solicitation, Drexel University was awarded a cooperative agreement entitled "Modular Photovoltaic Power Systems using Solar Fiber-Optic Mini-Dish Concentrators". Drexel University, with technical support from Ben Gurion University of the Negev of Isreal, will design, produce, assemble, test and demonstrate prototype mini-dishes and a one-kilowatt photovoltaic mini-dish power system. The two-year agreement with Drexel University is value at $646,401 with DOE contributing $527,668.

Objectives: Cleveland State University's research team, with support from Stirling Technology Company, Sunpower, and Bekaert Fibre Technologies, is embarking on fundamental research to advance the Solar Dish/Converter Technology through significant performance improvements to a crucial component of the Stirling engine converter, the regenerator. The objective of Drexel's research program, entitled Modular Photovoltaic Power Systems using Solar Fiber-Optic Mini-Dish Concentrators, is the experimental realization of a conceptual innovation in modular collection and delivery of solar energy with small dishes for photovoltaic power generation.

Approach: Under Cleveland State University's three-year research project, entitled Improving Performance of the Stirling Converter: Redesign of the Regenerator with Experiments, computation and Modern Fabricatrion Techniques, advancements in regenerator performance and modeling will be made by: 1) measurements in a representative regenerator system under oscillatory flow conditions to reveal its fundamental flow and heat transfer behavior; 2) using such measurements in the development of advanced CFD models of the regenerator which will be used to improve 1-D Stirling engine system models; 3) using such measurements in support of design rules regarding plenum space, porosity and bypass control; 4) using the measurement apparatus, CFD, and the 1-D system model to guide the development of modern regenerator matrix material for the next generation engine; and 5) updating the engine modeling to enable improvements in the solar Dish/Stirling System modeling. It is anticipated that resulting advancements in regenerator performance will result in improvements in overall Dish/Stirling system efficiency and power for given heat input. Under the research project, Drexel University will prove the concept and demonstrate the design, construction and operation of a 1kWe prototype system. The demonstration is intended to establish the credibility and viability of the concept for subsequent commercial development. Drexel's research program involves two phases, spanning one year each. The first phase will embody the design, production,

assembly, lab and field-testing and demonstration of a few prototype mini-dishes, while the second phase will involve the construction and field-testing and operation of a one-kilowatt photovoltaic mini-dish power plant that should operate at a net conversion efficiency in excess of 20%. Toward providing thorough experimental documentation for future system designs, Drexel will be determining the energetic gains, as well as the optical, thermal and mechanical performance, of each element in the system.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.0	0.0		0
FTE $	0	0		0
Purchase $	0	0		0
R&D Contract $	0	0	170	170
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	170

Milestones

MS	Milestone	Staff	Due Date
a	Award Cooperative Agreement to Drexel University	Other	12/2000
b	Finalize Design and Test Section for Fabrication (Cleveland State University)	Other	03/2001
c	Begin Base Case Regenerator Testing (Cleveland State University)	Other	09/2001
d	Complete Prototype Design (Drexel University)	Other	03/2001
e	Construct Mini-Dish Concentrator Prototypes (Drexel University)	Other	09/2001

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Brief Title: Microturbine Solar Dish Feasibility

Activity Title: Evaluate feasibility of developing a solar version of the commercially available Capstone Gas Turbine for use on a dish system

WBS Number: 1.4.5 **Staff:** Moss, Sandia

Path: Distributed Power **Priority:** 4

Primary Activity: Other Path 1

Background: Capstone Corporation has spent $200 M developing a 30 kW gas turbine for distributed power applications and British Gas (SolarPACES EXCO member) is actively selling units. Recently, DOE gave Capstone $10M to continue development of the system. The Capstone Gas Turbine is the first commercially available Brayton engine in modern history that is capable of

being driven by a dish concentrator. It is a good match with the WGA dish and DLR receiver.

Objectives: Our objective in FY01 is to determine the feasiblity of integrating the Capstone turbine with a solar dish. If feasible, in future years, we will build and test a prototype Capstone Power Conversion Unit (PCU), and, with active Capstone leadership, eventually develop a commercial solar product, including the concentrator, controls, receiver, i.e., a system.

Approach: In FY 01, Sunlab will work with Capstone and DLR to perform a feasibility study. We will contract with Capstone, but DLR will work for free through our SolarPACES connection. Pressure drops and configurational complexity will be assessed to determine if a solar product option is feasible. If the feasibility study is positive, in year 2 we will work with Capstone to develop a "proof-of-concept" prototype. The prototype could be developed for the TBC or the WGA dish. (DLR has a receiver designed for the TBC and has develped and produced a receiver for the WGA dish.) We will also team with British Gas and others to build a business plan. We will try to spark the interest of industry to bring positive exposure to the CSP program.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.193	0.0		0
FTE $	50	0		50
Purchase $	0	0		0
R&D Contract $	20	0	0	20
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	70

Milestones

MS	Milestone	Staff	Due Date
a	Establish contract with Capstone to perform feasibility study	Moss	05/2001
b	Complete Capstone feasibility study and recommendations for FY02 activities	Moss	09/2001

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Brief Title: Trough Receiver Development
Activity Title: Low-Cost High-Performance Receiver Development
WBS Number: 2.1.1 **Staff:** Mahoney, Sandia
Path: Dispatchable Power **Priority:** 1
Primary Activity: Trough Technology

Background: Currently, the only commercially available HCE is manufactured by SOLEL, in Israel. The current HCE design uses an evacuated receiver fabricated

from stainless steel tubing, coated with a cermet absorber, a Pyrex® glass envelope coated with an anti-reflection coating, and a conventional glass-to-metal seal technology. The current purchase (first) cost of the SOLEL HCEs is between $800 and $1,000 each. System studies of trough technology indicate that the capital investment impact of the HCEs range from 8 to 12% of the total new plant cost. In order to achieve future trough technology cost targets, the first cost of the receiver needs to be reduced to about $250 each without significantly impacting the thermal performance of the HCE.

Objectives: Develop, in conjunction with an industry partner capable of becoming a viable supplier, low-cost high-performance alternative trough receiver(s)

Approach: a)Evaluate current and low-cost alternative trough receiver economic drivers which includes durability and replacement costs. b) Collaboratively develop, with industry input, alternative low-cost trough receivers which include both non-evacuated and evacuated approaches. c) Evaluate possible absorber coatings and alternative glass-to-metal seal approaches using accelerated, laboratory methods and techniques. d) Conduct an industry/lab design review (HCE Workshop). e) Decide on prototype receiver designs based upon HCE Workshop feedback, accelerated laboratory testing, and fabricate for testing. f) Field test and evaluate prototype receiver(s) using task ordering agreements with the SEGS plants.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	1.21	0.0		1
FTE $	314	0		314
Purchase $	165	0		165
R&D Contract $	30	0	241	271
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	750

Milestones

MS	Milestone	Staff	Due Date
a	Conduct HCE Workshop, during ASME/ASES/Soltech, and document results	Mahoney	05/2001
b	Initiate field testing of prototype low-cost high-performance HCEs at one or more SEGS plants (key)	Mahoney	09/2001

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Brief Title: Near-Term Trough Concentrator
Activity Title: Near-Term Trough Concentrator
WBS Number: 2.1.2

Staff: Price, NREL

Path: Dispatchable Power **Priority: 3**

Primary Activity: Trough Technology

Background: There are a number of upcoming international, as well as some potential domestic, projects for commercial trough power plants. Although parabolic trough technology is generally recognized to be a well-developed and highly demonstrated solar technology, currently it is not clear what collector a developer would use if a project were built today. The most readily available design is the Luz LS-3 collector that Solel (an Israeli company) has the ability to provide. However, poor performance and maintainability issues make this design less desirable. The IST collector has not been demonstrated at the higher operating temperatures needed for power applications. The Luz LS-2 design has desirable performance and maintenance characteristics, but has intellectual property ownership issues and could also benefit from a freshening. The EuroTrough is a new and untested design developed to improve the LS-3 and make it more like the LS-2, and licensing rights are available to U.S. companies. Duke solar is evaluating a novel new structure, but it will need significant development and testing before it is ready to be used in a commercial project.

Objectives: Identify a U.S. company interested and capable of supplying the solar field for a near-term trough project. Working with the company, jointly develop a trough design with an appropriate level of technical risk for near-term projects. Finally, test the trough design rigorously to quantify its performance and prove its viability.

Approach: The approach is to offer an open procurement for a near-term trough concentrator, select the best proposal, and create a SunLab/industry team to perform design work. After a design has been completed and reviewed, prototypes must be built and tested. Most likely, a single prototype segment will first be performance tested, followed by testing of a full loop. This is a multi-year project. Once direction of activity is determined and contracts placed, appropriate milestones will be defined and implemented.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.75	0.174		0
FTE $	195	40		235
Purchase $	75	5		80
R&D Contract $	0	0	185	185
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	500

Milestones

MS	Milestone	Staff	Due Date
a	Place a contract for cooperative trough concentrator development with an industry partner capable of future supply to the trough industry	Jones	04/2001

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Brief Title: USA Trough Phase II
Activity Title: USA Trough Initiative Phase II
WBS Number: 2.1.3 **Staff:** Price, NREL
Path: Dispatchable Power **Priority:** 1
Primary Activity: Trough Technology

Background: Parabolic trough technology has been identified as the leading CSP technology in a number of potential near-term projects. The USA Trough Initiative is intended to provide U.S. industry the opportunity to develop competitive products and services for the market as it develops.

Objectives: The overall objective of the USA Trough Initiative is to help develop a U.S. Trough industry that will be better positioned to compete in domesic and international trough projects. This objective is accomplished through the support of industry directed R&D efforts that advance the state of the art of parabolic trough technology, integration, and services to improve the near-term (one to five years) competitiveness of the technology. Specific activities will reduce cost, improve performance, improve reliability, reduce commercial risk, or affect other factors to improve the competitiveness of trough technology.

Approach: SunLab will manage the six FY00 USA Trough activities and provide technical support requested by industry in the FY00 awards. Issue competitive RFPs to (1) extend existing USA Trough research and development (R&D) activities and (2) generate new R&D activities. The goal is to have a minimum of three new or extension activities. Some of the funds may be used for directed efforts based on feedback from industry and stakeholders. In particular, some of this money could be used to augment receiver tube, concentrator, or small system efforts. The Current FY00 USA Trough contracts include: - Industrial Solar Technology – Development of a higher temperature version of their concentrator for solar power applications, - State University of New York – Development of a methodology for generating high resolution DNI data from satellite images, - Augustyn and company – Development of a low cost DNI monitoring system with improved accuracy, - Kearney & Associates – Assessment of molten-salt HTF at a SEGS plant - Reflective Energies – Development of an optimized design of a small trough ORC plant, and - Duke Solar – Optimization of new concentrator structure and secondary reflector, and optimization of trough ORC plant.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.0	1.34		1
FTE $	0	308		308
Purchase $	0	40		40
R&D Contract $	0	550	0	550
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	898

Milestones

MS	Milestone	Staff	Due Date
a	Kearney & Associates Molten-Salt HTF for Trough Decision to Proceed	Blake	04/2001
b	Complete Optimized IST Concentrator Design for Power Applications	Hale	12/2001
c	Complete Duke Solar Optimization of Advanced Trough Concentrator Design	Hale	09/2001
d	Conplete Reflective Energies Optimized Trough ORC Design	Price	09/2001
e	Complete placement of all six FY00 Contract Awards	Price	02/2001

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Brief Title: Thermocline Storage System
Activity Title: Near-Term Trough Thermal Storage
WBS Number: 2.2.1 **Staff:** Pacheco, Sandia
Path: Dispatchable Power **Priority:** 1
Primary Activity: Trough Technology

Background: Economical and reliable near-term thermal storage is a necessary part of the development of trough technology. It will lead to dispatchable, solar-only trough plants and/or increased solar capacity factor. This, in turn, will expand strategic markets and reduce risk associated with the technology. Last fiscal year, a major develop activity was begun to determine the techncial feasibility and performance of a molten-salt thermocline storage system. Filler materials were screened. Candidate materials were thermally cycled and a small 1.5 MWh thermcline pilot test was built. We also conducted salt safety studies to address issues related to have an oxidizer in close proximity to a fuel. A thermocline storage system will reduce the cost of storage relative to a two-tank molten salt system. This activity supports the USA Trough activities of Nexant (Thermal Storage Integration with Troughs) and Kearney and Associates (Engineering Evaluation of Molten Salt HTF in Parabolic Trough Solar Fields)

Objectives: The objective of this task is to complete the development and testing of the thermocline storage system and document the results.

Approach: We will complete testing of the pilot-scale thermocline system and document the results.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.5	0.0		0
FTE $	130	0		130
Purchase $	100	0		100
R&D Contract $	26	0	0	26
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	256

Milestones

MS	Milestone	Staff	Due Date
a	Complete testing and final documentation of thermocline system (key)	Pacheco	02/2001

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Brief Title: Advanced Thermal Storage Fluid
Activity Title: Advanced Thermal Storage Fluid
WBS Number: 2.2.2 **Staff:** Blake, NREL
Path: Dispatchable Power **Priority:** 3
Primary Activity: Trough R&D

Background: Current trough systems for electricity production use synthetic oils as the heat transfer fluid. These have a number of limitations that prevent their use as media for direct storage of thermal energy. New approaches are required and significant improvements in thermal storage economics and operability are necessary for significant expansion of trough technology into the electric power generation market to occur. Although near-term storage options hold promise for increasing the value of the technology, successful advanced storage technologies will dramatically improve both the value and the economics of trough technology for the long term. Organic molten salts (termed ionic liquids in the chemical engineering and synthetic chemistry community) having properties that match the requirements of trough systems were identified in FY00. These materials include examples that have melting points below 0 C (32 F), zero (or very low) vapor pressure up to the temperature of decomposition, and thermal stability at the temperatures required for trough applications. In FY00 a two year subcontract was awarded to the University of Alabama Center for Green Manufacturing and Department of Mechanical Engineering to evaluate thermal storage, heat transfer, materials compatibility, and factors influencing the production cost of representative ionic liquids. NREL began a compilation of known materials, utilized existing capability to synthesize new examples of ionic liquids, and established capability for measuring thermal stability.

Objectives: The objectives for FY01 are to (1) investigate potential "showstopper issues" (such as fluid cost, toxicity, materials compatibility) to provide an early go/no-go decision for advanced storage using ionic fluids, and (2)

identify one or more promising ionic fluids for use in an advanced storage design.

Approach: Effort will be on identification of fluids that can be used for direct storage in trough systems for generating electricity. This will be focussed on the new classes of low temperature organic molten salts, ionic liquids. Approaches will be tested that use pure ionic liquids, mixtures of ionic liquids, or other innovative ways that can use the desirable properties of ionic liquids in a thermal storage system for trough plants. Known materials that are identified in the literature and new compounds synthesized at NREL or The University of Alabama will be evaluated. Measurements of the key physical and chemical properties for this application will be determined for selected materials and formulations either at NREL or The University of Alabama. The performance and economics of these approaches will be subjected to a preliminary evaluation. A lower level of effort will continue to be directed to identifying the current state of the art and direction of development for phase change and chemical storage media and other storage options that may become applicable to use in trough systems. The project team will coordinate efforts with subcontractors and as appropriate with the Near Term Thermal Storage Task.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.193	0.522		0
FTE $	50	120		170
Purchase $	10	20		30
R&D Contract $	0	50	30	80
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	280

Milestones

MS	Milestone	Staff	Due Date
a	Complete evaluation of showstopper issues for advanced thermal storage fluids (key)	Blake	06/2001
b	Document research on ionic fluids and identify the most promising approaches	Blake	09/2001

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Brief Title: Trough Technical Support
Activity Title: Technical Support to Trough Industry
WBS Number: 2.3.1 **Staff: Price, NREL**
Path: Dispatchable Power **Priority: 4**
Primary Activity: Trough Technology

Background: Trough technology represents the most mature solar power plant technology with a proven operational track record. However, as the existing plants age there are a number of technical issues that need to be addressed to assure the long-term performance of existing and future plants.

Objectives: This effort provides technical support to trough industry and stakeholders on an as needed basis. Support to existing O&M companies, solar technology and development companies, and others.

Approach: This effort will focus on two of the key technical issues facing the O&M companies of the existing SEGS plants, primarially maintaining alignment of the LS-3 collectors, and availability of replacement mirrors. There is evidence that the LS-3 collectors at SEGS VII-IX have not maintained there original optical alignment over the last 10 years. The O&M companies would like to find the best ways to assess and correct the alignment problems that exist. SunLab will work with KJCOC and FPL Energy to evaluate the alignment of the LS-3 collectors and work to develop the tools and procedures for aligning LS-3 collectors. SEGS O&M companies are interested in finding an alternative replacement mirror panel that will be stronger in high wind conditions, cost the same or less than Flabeg mirrors, and not require orders that represent multi-year replacement quanties. The high cost of the Paneltech mirror does not appear to satisfy the requirements of the plants. KJCOC is working on an alternative design. SunLab will provide technical support to KJCOC and the other O&M companies in support of this effort.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.154	0.131		0
FTE $	40	30		70
Purchase $	0	15		15
R&D Contract $	0	45	0	45
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	130

Milestones

MS	Milestone	Staff	Due Date
a	Complete initial support plan with SEGS O&M Companies	Price	04/2001

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Brief Title: Technical Support to Solar Tres

Activity Title: Technical Support to Industry for Solar Tres

WBS Number: 2.3.2 **Staff: Pacheco, Sandia**

Path: Dispatchable Power **Priority: 1**

Primary Activity: Power Tower Technology

Background: Industry is working internationally to develop and build the first commercial power tower plants. Industry has requested our continued support in advancing the technology to the point of commercialization. Industry has provided us with an extensive list of requested activities. We have worked with industry to prioritize these requests and developed a program to address the highest priorities. Industry has made a request for DOE to support specific technical tasks through tests and evaluations.

Objectives: Resolve specific technical issues related to molten-salt power towers and commercialization of the first plant.

Approach: The highest priority tasks as identify by industry and SunLab staff will be addressed in this task. Specifically, we will test lower maintenance valves, measure corrosion rates of materials proposed for piping and vessels, develop a head reducing downcomer, and assist industry in developing and testing heliostat components for the first commercial plant. Staff will interface with Nexant and provide expertise and consultation. Areas of support include: Receiver, piping, valves, instrumentation, heliostats, steam generator system, and heat trace.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	2.5	0.0		2
FTE $	650	0		650
Purchase $	149	0		149
R&D Contract $	0	0	0	0
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	799

Milestones

MS	Milestone	Staff	Due Date
a	Complete Testing of a Head Reducing Downcomer with Water	Pacheco	05/2001
b	Present Results of Testing and Development Activities to Industry (Key)	Pacheco	09/2001
c	Complete Testing of Heliostat Components	Jones	07/2001

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Brief Title: General Systems Support
Activity Title: General Systems Support
WBS Number: 3.1.1 **Staff: Jones, Sandia**
Path: Advanced Components and Systems **Priority: 1**
Primary Activity: Systems Analysis and Field Operations
Background: This activity covers the typical systems analysis activities that occur during the year. During FY2000 this included systems analysis in support of the Mexico GEF feasibility study led by Spencer Management and interactions with LBNL and PERI on CSP projections for the EIA.
Objectives: 1) Provide systems support to high-visibility CSP projects

2) Help justify CSP program funding by working with policy groups to improve CSP market penetration predictions.
Approach: We will work with the EIA, LBNL, and PERI to improve CSP market penetration predictions for the National Energy Modeling System results that are published in the Annual Energy Outlook. In parallel, we will explore other appropriate avenues, including collaborating with different policy groups on alternate models. We will support industry needs for systems analysis on an as-needed basis.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.158	0.066		0
FTE $	41	15		56
Purchase $	38	0		38
R&D Contract $	24	0	0	24
Carry Over $	0	0	0	0
Total (FTE+Purchases+R&D)				118

Milestones

MS	Milestone	Staff	Due Date
a	Improve the CSP market penetration predictions by independant analysts	Jones	09/2001

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Brief Title: Resource Assessment

Activity Title: Assessment of Direct Normal solar resources for CSP siting.

WBS Number: 3.1.2 **Staff:** Renne, NREL

Path: Advanced Components and Systems **Priority:** 1

Primary Activity: Systems Analysis and Field Operations

Background: The US CSP industry has strongly urged that SunLab devote some effort in developing and providing industry with improved solar resource data and products. This task supports industry and related SunLab projects with the development and dissemination of reliable solar resource data for effective deployment of CSP systems, domestically and world-wide.

Objectives: Develop and apply tools and methodologies for producing high quality solar resource data and related products to support US industry and SunLab activities at specific sites worldwide, and to optimize the siting process in given regions.

Approach: Apply resource assessment tools (e.g. time series analyses, the Climatological Solar Radiation (CSR) model and other solar resource mapping methodologies, Geographic Information Systems) and databases (e.g. DATSAV2 international surface meteorological data, RTNEPH international gridded cloud cover data, geostationary satellite data) for specific site analyses and for regional site optimization studies as defined by industry and other CSP stakeholders. Specific direct support will be provided to industry, as requested through SunLab, for one site-specific or regional study.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.0	0.435		0
FTE $	0	100		100
Purchase $	0	0		0
R&D Contract $	0	0	0	0
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	100

Milestones

MS	Milestone	Staff	Due Date
a	Report on prototype study for one proposed CSP power plant site or region. Location to be chosen based on industry input.	Renne	09/2001

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Brief Title: Facilities O&M

Activity Title: Facilities Operations and Maintenance and Rotating Platform upgrade.

WBS Number: 3.2.1 **Staff: Kolb, Sandia**

Path: Advanced Components and Systems **Priority: 1**

Primary Activity: Systems Analysis and Field Operations

Background: The NSTTF at Sandia and the HFSF at NREL were built to support DOE's Renewable Energy Program. These facilities have been an important part in testing and evaluating solar components and systems since the late 1970s. The need for quality facilities is required to support the growth of the CSP program.

Objectives: Operate and maintain high quality test facilities to provide high flux/high temperature testing and evaluation capabilities to support the Renewable Energy Program. Ensure these facilities are in compliance with ES&H requirements. Also upgrade portions of the rotating platform to support trough component testing.

Approach: Provide quality test facilities to support the development, testing, and evaluation of new technologies.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.866	0.131		0
FTE $	225	30		255
Purchase $	305	17		322
R&D Contract $	0	0	0	0
Carry Over $	0	0	0	0
		Total (FTE+Purchases+R&D)		577

Milestones

MS	Milestone	Staff	Due Date
		Kolb	09/01
a	Provide quality, ES&H-incident-free facilities in support of the CSP Renewable Energy Program and CSP testing. Upgrade the rotating platform's controls, drive and measuring units to better support trough component testing.	Kolb	09/2001

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Brief Title: Optical Testing

Activity Title: Maintain current capability to test optical performance of candidate solar mirrors

WBS Number: 3.3.1 **Staff: Jorgensen, NREL**

Path: Advanced Components and Systems **Priority: 1**

Primary Activity: Advanced Materials

Background: The comprehensive capability for testing of candidate optical materials that has been developed within SunLab will be used to evaluate optical materials currently used by industry. Optical characterization equipment will be used to measure optical performance initially (unweathered) and periodically as a function of accelerated weathering exposure (in a Ci65 WeatherOmeter and/or in solar simulator exposure chambers). A need exists for an improved (in terms of accuracy and ease of use) method for measuring specular reflectance; development of a device that accomplishes this will be pursued as time and manpower permit.

Objectives: Provide support for reducing concentrator costs while maintaining high performance

Approach: Approach: Use core testing capabilities for:
- Optical characterization
- Exposure testing protocols
- Evaluation of protective paints and adhesives used with glass mirror constructions

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.0	0.566		0
FTE $	0	130		130
Purchase $	0	33		33
R&D Contract $	0	0	0	0
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	163

Milestones

MS	Milestone	Staff	Due Date
a	Update test results of candidate solar mirror samples and identify promising candidates.	Jorgensen	09/2001

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Brief Title: Fundamental Analysis

Activity Title: Expand analysis and develop a fundamental understanding of material failures

WBS Number: 3.3.2 **Staff: Jorgensen, NREL**

Path: Advanced Components and Systems **Priority: 1**

Primary Activity: Advanced Materials

Background: Extensive analytical capabilities that exist within SunLab will be used to investigate mechanisms of material degradation and failure. We will work with the existing solar manufacturing industry to understand their problems through more field visits, outreach presentations on materials R&D, and enhancing our responsiveness to problems identified. If necessary, we will also fabricate candidate optical materials in the lab to test theories of degradation and point the way to new and improved solar material products.

Objectives: Understand failure modes and degradation mechanisms to allow industry to fabricate improved materials

Approach: - Use analytical capabilities available within context of SunLab-industry team
- Fabricate candidate optical materials in the lab to test theories of degradation
- Conduct field visits, outreach presentations, enhanced responsiveness to problems identified

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.374	0.435		0
FTE $	97	100		197
Purchase $	7	7		14
R&D Contract $	0	0	0	0
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	211

Milestones

MS	Milestone	Staff	Due Date
a	Identify reasons for failure of thin glass mirrors and recommend solutions to industry to avoid further problems in the field.	Jorgensen	02/2001

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Brief Title: Outdoor Testing
Activity Title: Maintain Outdoor Test Procedures & Analysis
WBS Number: 3.3.3 **Staff: Jorgensen, NREL**
Path: Advanced Components and Systems **Priority: 2**
Primary Activity: Advanced Materials

Background: We will continue our effort in testing reflector materials for solar thermal concentrator applications. This provides data on performance losses as a function of exposure time at a number of locations that are attractive to utilities and industrial companies interested in concentrated solar power generation. Presently, the weather monitoring dataloggers at 4 out of 5 of our US test sites are inoperable; this problem will be resolved as a high priority concern during FY01.

Objectives: - Enable an understanding of why materials degrade differently at geographically diverse locations
- Allow quantitative predictions of material service lifetimes to be made

Approach: - Consolidate and reactivate outdoor test sites
- Leverage SolarPACES collaboration through use of international outdoor testing network

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.0	0.261		0
FTE $	0	60		60
Purchase $	0	0		0
R&D Contract $	0	0	0	0
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	60

Milestones

MS	Milestone	Staff	Due Date
a	Reduce laboratory staffing needs by consolidating operation of US outdoor exposure test site network (including subcontracted oversight of two sites).	Jorgensen	04/01

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Brief Title: Screen New/Advanced Materials

Activity Title: Screen New/Advanced/Improved Materials Using a Hierarchy of Increasingly Complex Tests

WBS Number: 3.3.4 **Staff: Jorgensen, NREL**

Path: Advanced Components and Systems **Priority: 2**

Primary Activity: Advanced Materials

Background: New/improved candidate solar mirror samples will be evaluated for next-generation concentrator design applications. We will use and refine our qualification screening test regimen developed during FY00 to quickly identify materials with poor durability, to distinguish samples with high infant mortality rates, and to minimize testing costs. Candidate materials that pass coupon-sized test protocols will be deployed in the field as prototype/demonstration solar concentrator elements.

Objectives: - Provide industry with the ability to fabricate and evaluate new constructions
- Provide greater confidence in use of materials through field test results

Approach: - Continue SAIC - McLean, VA subcontract to develop super-thin glass mirrors
- Develop new standards and screening/qualification test procedures
- Test coupon sized samples; perform failure analysis; improve materials; deploy prototype structures in field

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.0	0.218		0
FTE $	0	50		50
Purchase $	0	3		3
R&D Contract $	0	138	0	138
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	191

Milestones

MS	Milestone	Staff	Due Date
a	Demonstrate (SAIC, McLean, VA) ability to fabricate super-thin glass mirror material using a roll-coating process.	Jorgensen	06/2001

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Brief Title: CSP Program Communications
Activity Title: CSP Program Communications Support
WBS Number: 3.4.1 **Staff:** Tyner, Sandia
Path: Advanced Components and Systems **Priority:** 1
Primary Activity: Other Path 3
Background: Increased visibility of CSP is critical to future support from DOE and Congress. Industry input has also indicated that increased visibility and communication is critical. This increased effort (relative to last year) will meet these needs.
Objectives: Increase CSP visibilty with Congress and DOE management; increase communications with CSP industry; and enhance public visibility of CSP
Approach: Coordinate with industry on necessary communications tools that will support their needs. Consolidate CSP and SunLab websites, and keep key information current. Develop and populate new web-based database supporting DOE's SMS system.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.674	0.0		0
FTE $	175	0		175
Purchase $	82	0		82
R&D Contract $	0	0	0	0
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	257

Milestones

MS	Milestone	Staff	Due Date
a	Consolidate CSP and SunLab websites	Tyner	6/2001
b	Implement web-based database management system	Tyner	3/2001

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Brief Title: Special Studies

Activity Title: Special Studies on the Status of CSP Technologies and Markets

WBS Number: 3.4.2 **Staff:** Mancini, Sandia

Path: Advanced Components and Systems **Priority:** 1

Primary Activity: Systems Analysis and Field Operations

Background: In order to better integrate CSP Program Plans with industry, we need to develop a clearer understanding of the status of our technologies and the potential markets for them. It is best if this perspective come from a third-party observer.

Objectives: To develop a clearer "picture" of the technology and market status of CSP technologies.

Approach: Place contracts with AD Little and Energy and Environmental Consultants to perform technology and market evaluations of CSP technologies.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.231	0.0		0
FTE $	60	0		60
Purchase $	0	0		0
R&D Contract $	75	0	50	125
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	185

Milestones

MS	Milestone	Staff	Due Date
a	Complete EEC Market Study	Mancini	02/2001
b	Complete AD Little Technology Status Study	Mancini	03/2001
c	Peer Review of CSP Program	Mancini	08/2001

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Brief Title: SolarPACES Support
Activity Title: SolarPACES Support
WBS Number: 3.4.3 **Staff:** Tyner, Sandia
Path: Advanced Components and Systems **Priority:** 1
Primary Activity: Other Path 3

Background: The International Energy Agency's CSP working group, SolarPACES, is a mechanism for international information-, task-, and cost-sharing of CSP technologies and projects among its 14 member countries. It has been a mechanism for leveraging our CSP investments internationally for many years.

Objectives: Our objectives within SolarPACES are to keep abreast of advances in CSP technologies and opportunities for major CSP projects worldwide, and to share tasks and costs of major CSP activities on a mutually beneficial basis with other SolarPACES-member CSP programs.

Approach: We will participate in SolarPACES activities by
- leading key SolarPACES activities (as operating agents and sector leaders) to ensure beneficial direction of key activities;
- supporting SolarPACES START missions and related activities to potential market countries; and
- implementing cooperative projects (remote dish, engine exchange, etc.) that meet our program objectives and leverage our resources.

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.154	0.044		0
FTE $	40	10		50
Purchase $	10	20		30
R&D Contract $	0	0	0	0
Carry Over $	0	0	0	0
			Total (FTE+Purchases+R&D)	80

Milestones

MS	Milestone	Staff	Due Date
a	Complete SolarPACES Task I annual report input	Tyner	03/2001

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Brief Title: HQ Holdback - Congressional
Activity Title:
WBS Number: 4.1 **Staff: Other,**
Path: Other **Priority: 1**
Primary Activity: Headquarters Support
Background:
Objectives:
Approach:

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.0	0.0		0
FTE $	0	0		0
Purchase $	0	0		0
R&D Contract $	0	0	250	250
Carry Over $	0	0	0	0
Total (FTE+Purchases+R&D)				250

Milestones

MS	Milestone	Staff	Due Date

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Brief Title: HQ Holdback - EE/OPT Collaboration
Activity Title:
WBS Number: 4.2 **Staff: ,**
Path: Other **Priority: 1**
Primary Activity: Headquarters Support
Background:
Objectives:
Approach:

	Sandia (260k/FTE)	NREL (230k/FTE)	DOE	Total
FTEs	0.0	0.0		0
FTE $	0	0		0
Purchase $	0	0		0
R&D Contract $	0	0	350	350
Carry Over $	0	0	0	0
Total (FTE+Purchases+R&D)				350

Milestones

MS	Milestone	Staff	Due Date

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Concentrating Solar Power Program

FY01 AOP Budget

		Sandia				NREL				DOE	CSP			
		FTE$	Pur-chases	R&D Contr	Total	FTE$	Pur-chases	R&D Contr	Total	Total	FTE$	Pur-chases	R&D Contr	Total
CSP Total	WBS	3150	1330	2600	7080	1680	240	3324	5244	1476	4830	1570	7400	13800
Path 1. Distributed Power		1133	363	2471	3967	687	80	2541	3308	370	1820	443	5382	7645
Grid Reliability Systems	1.1	260	54	1658	1972	164	10	1950	2124	200	424	64	3808	4296
Remote Power Systems	1.2	689	305	793	1787	0	0	0	0	0	689	305	793	1787
Reliability Improvement	1.3	94	4	0	98	90	4	0	94	0	184	8	0	192
Diversified Small Systems	1.4	90	0	20	110	433	66	591	1090	170	523	66	781	1370
Path 2. Dispatchable Power		1379	525	30	1934	498	80	645	1223	456	1877	605	1131	3613
Advanced Dev & Systems Testing	2.1	509	240	30	779	348	45	550	943	426	857	285	1006	2148
Storage and Hybridization	2.2	180	136	0	316	120	20	50	190	30	300	156	80	536
Tech Support to Industry Projects	2.3	690	149	0	839	30	15	45	90	0	720	164	45	929
Path 3. Adv Component Research		638	442	99	1179	495	80	138	713	50	1133	522	287	1942
System Analysis	3.1	41	38	24	103	115	0	0	115	0	156	38	24	218
Facilities	3.2	225	305	0	530	30	17	0	47	0	255	322	0	577
Optical Materials	3.3	97	7	0	104	340	43	138	521	0	437	50	138	625
Communications	3.4	275	92	75	442	10	20	0	30	50	285	112	125	522
HQ Holdback		0	0	0	0	0	0	0	0	600	0	0	600	600
Congressional	H.1	0	0	0	0	0	0	0	0	250	0	0	250	250
EE/OPT Collaboration	H.2	0	0	0	0	0	0	0	0	350	0	0	350	350

Specified Dissemination Only

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