Solar
Thermal
Energy

The DOE

Solar Thermal Electric Program

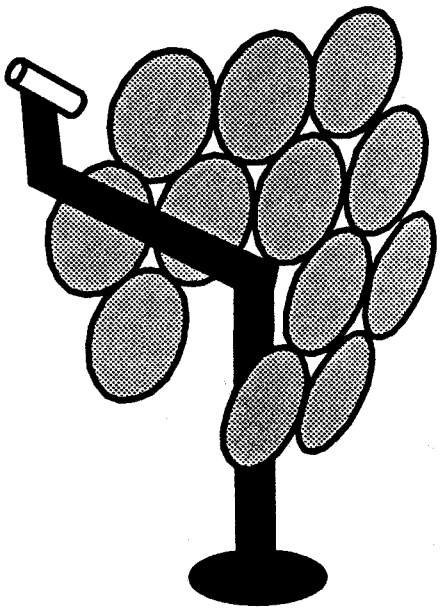
Quarterly Progress Report
Fourth Quarter, Fiscal Year 1991

Submitted by:

Sandia National Laboratories
Albuquerque, New Mexico

National Renewable Energy Laboratory
Golden, Colorado

October, 1991



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FOREWORD

The research and development described in this report were conducted within the U.S. Department of Energy's (DOE) Solar Thermal Electric Technology Program. This document is prepared jointly and reports the work of both major field laboratories, Sandia National Laboratories (SNL) and the National Renewable Energy Laboratory (NREL), and their contractors.

This quarterly progress report is written to the Solar Thermal Electric Program's Annual Operating Plan (AOP) approved on March 19, 1991.

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MANAGEMENT STATUS REPORT

Structure of the Solar Thermal Electric Technology Program

The Solar Thermal Electric Technology Program has shifted its emphasis from research and development to a commercial, applications-driven set of cooperative activities with heavy industrial involvement in both planning and execution. The purpose of this shift is to accelerate the commercialization of solar thermal electric technology. By closely linking the program to private sector needs, specific activities support early market penetration of the technology, and program resources are more highly leveraged. Government/industry partnerships produce teams uniquely qualified to accomplish this. The partnerships combine the manufacturing, marketing, and management skills of industry with the solar-specific experience base and analytical and experimental capabilities of the laboratories.

Under this scenario, the program is divided into two main categories: Commercial Applications and Technology Development. Commercial Application activities will determine the overall direction of the program. Technology Development efforts in the concentrator and power conversion tasks will support the Commercial Applications task. Relative to earlier fiscal years, technology development milestones focus on nearer timeframes, and far-term research plays a reduced, but continuing, role. The FY91 structure of the program is outlined as follows:

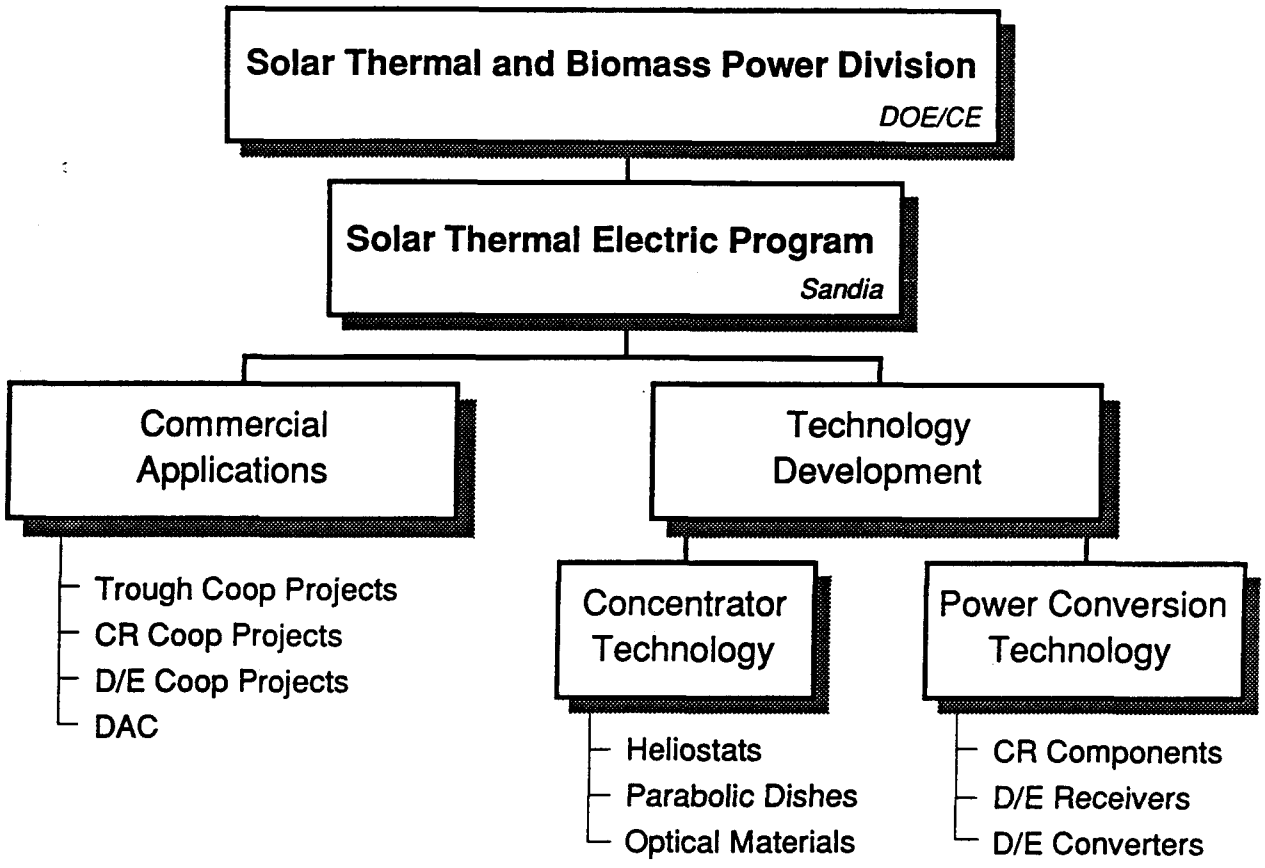
FY91 SOLAR THERMAL ELECTRIC PROGRAM

I COMMERCIAL APPLICATIONS
- A. Central Receiver Cooperative Projects
- B. Dish/Engine Cooperative Projects
- C. Parabolic Trough Cooperative Projects
- D. Design Assistance

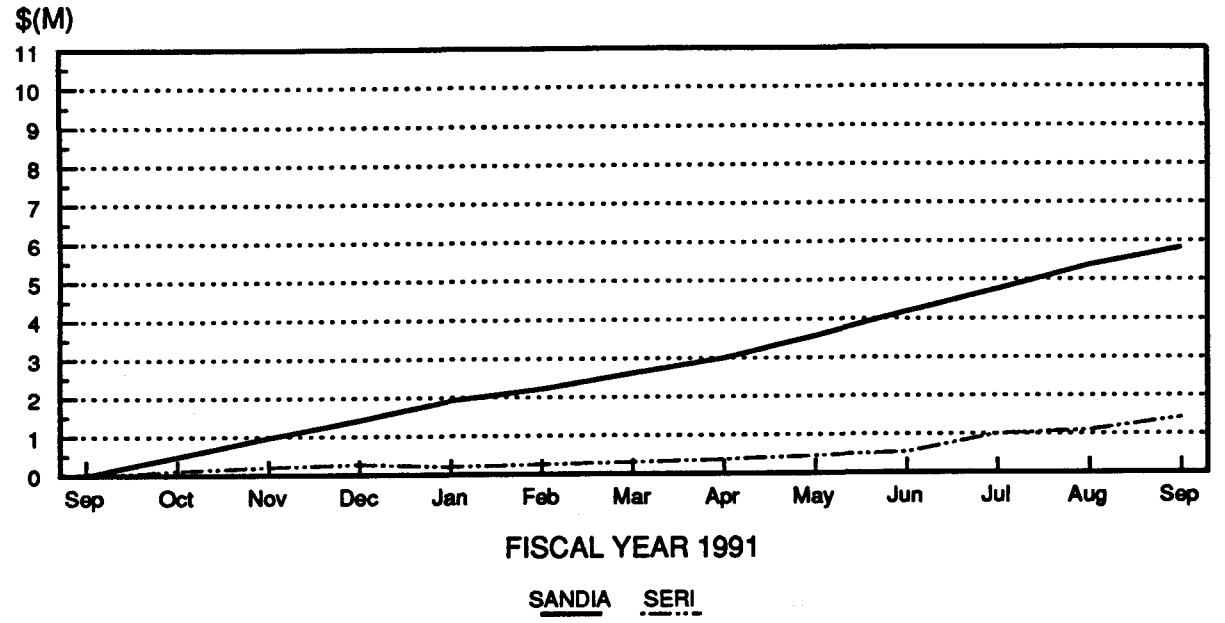
II TECHNOLOGY DEVELOPMENT
- A. Concentrator Technology
  1. Heliostats
  2. Parabolic Dishes
  3. Optical Materials
- B. Power Conversion Technology
  1. Central Receiver Technology
  2. Dish Receiver Technology
  3. Dish Converter Solarization Technology

Field Management - Structure and Responsibilities

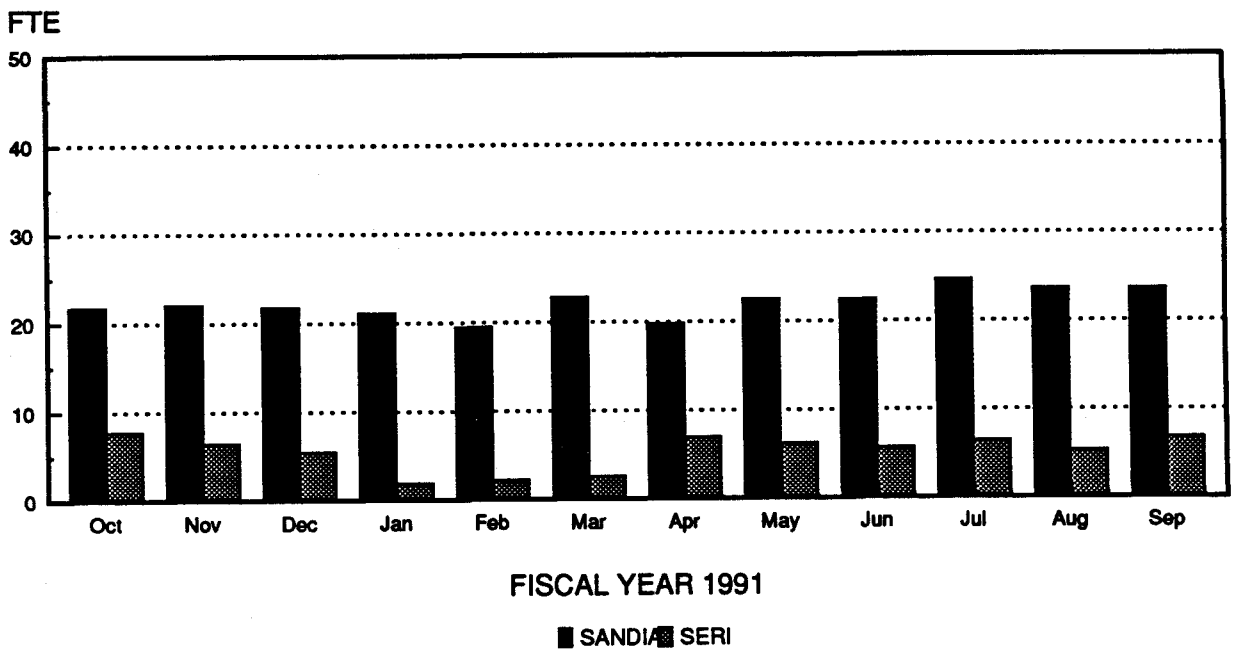
Specific implementation of the Solar Thermal Electric Technology Program is assigned to two field laboratories, Sandia National Laboratories in Albuquerque, New Mexico, and the National Renewable Energy Laboratory in Golden, Colorado. Sandia National Laboratories is the Program's lead laboratory. Together,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



CUMULATIVE BUDGET OUTLAY



MONTHLY MANPOWER LEVEL



Procurement Summary

SOLAR THERMAL ELECTRIC SUBCONTRACTS

Task	Specific Contract Subject	Contractor	Lab Contract Number	Present Contract Value ($K)	Prior Year Funds ($K)	FY 1991 Funds ($K)	Period of Performance	Contractor Type	Major Reports	Project Monitor
IIA1	Replaceable Membrane	IST	SNL42-9690	$50	$50	--	11/89 - 2/91	Small	91-7006	D. Alpert
IIA1	Heliostat Integration	Solar Kinetics, Inc.	SNL42-9691	$100	$100	--	10/89 - 1/91	Small	90-7038	D. Alpert
IIA1	Heliostat Fabrication	SAIC	SNL54-5780	$540	$400	$140	01/90 - 4/91	--	None	D. Alpert
IIA1	NSTTF Technician Services	Ewing Technical Design	SNL63-5487	$1,350	$450		04/89 - 04/92	--	TBD	E. Rush
IIA1	Coll. Supp. Struc.& Ped.	WGAssoc	SNL42-9815	$242 (est.)	--	$242	09/89 - 4/91	--	TBD	T. Mancini
IIA1	Faceted Dish Development	SKI SAIC	SNL42-9814B SNL42-9814A	$209 $238	-- --	$209 $238	09/89 - 4/91 (4/91)	Large	TBD	T. Mancini
IIA1	Stretched-Membrane Dish Dev.	Solar Kinetics, Inc.	SNL55-2495	$1,656	$500	--	04/88 - 12/91	Small	88-7035	T. Mancini
IIB2	Reflux Heat-Pipe Rec.	Stirling Ther. Motor	SNL33-3036	$245	$225	$20	04/87 - 7/91	Small	--	T. Moss
IIB1	Volm.Rec. Furnace Test	NMSU	SNL66-9967	$45	$30		01/90-12/90 (Extended to 12/91)	Univ.	--	J. Chavez
IIB3	2ndSTM4-120	Stirling Ther. Motor	SNL75-8851	$360	--	--	04/89 - 06/90	Small	--	P. Klimas

Procurement Summary (continued)

Task	Specific Contract Subject	Contractor	Lab Contract Number	Present Contract Value ($K)	Prior Year Funds ($K)	FY 1991 Funds ($K)	Period of Performance	Contractor Type	Major Reports	Project Monitor
IIB3	ASCS Design	NASA LeRC	DOE Inter-agency	$4369	1050	1035	01/89 - 01/93	Govt.	--	P. Klimas
II	Solar Test Support	EG&G	SNL05-4912	$150	$150		12/88 - 10/93	Large	--	C. Cameron
II	Electrical Support Service	J & S Electric Co., Inc.	SNL75-7415	$120	$60		02/89 - 02/92	Serv. Support	--	J. Stomp, Jr.
IIB3	Heater Heads	Stirling Therm Mtrs	SNL78-8095	$ 46	46		10/1 -12/31/90	Small	--	K. Linker
IIB2	Solar Rec. Heat Loss Testing	California Polytech	SNL02-5759	$105	$30		09/86 - 09/91	Univ.	ASME and ISES papers	A. Heckes
IIB2	STEP Test Program	Georgia Power	SNL42-4859	$42	$42		06/89 - 03/90	Large	Final Test Report	A. Heckes
IIB2	Heat-pipe	Cummins	SE10137-01	$65	$65		10/90	Large	TBD	M. Bohn
IIB2	Heat-Pipe	Cummins	SE11160-01	$75			07/91	Large	--	M. Bohn
IID	Tech Trans Documentation	Solar Energy Inds. Assoc.	SNL42-5186	$327	$187		3/90-2/92	Non-profit	Three TT Rpts.	D. Menicucci

NOTE - This list contains subcontracts exceeding $25,000.

Major Milestone Schedule

For reference, milestones identified in the FY 1991 Annual Operating Plan (AOP) for each program task are given below. This set of milestones forms the basis for progress reporting and tracking in this Quarterly Progress Report. Quarterly reports focus on the status of each milestone for the current quarter in the "Significant Accomplishments Summary."

Fiscal Year 1991

Lab	Date	Activity-Task Reference	Descriptive Title
First Quarter, FY 1991			
SN	December, 1990	IA	Make utility-scale central receiver presentation to review committee.
SN	October, 1990	IB	Issue request for proposal for Dish/Stirling Joint Venture.
SN	November, 1990	IIA1	SAIC completes fabrication of a prototype of its 100-m^2 market-ready heliostat.
SN	November, 1990	IIA1	SKI completes a design for its market-ready heliostat.
SN	November, 1990	IIA2	Complete testing of the 7-meter diameter SM optical element.
SN	November, 1990	IIA2	Phase 1 design review for the faceted dish project.
Second Quarter, FY 1991			
SN	February 1991	IA	Initiate utility-scale central receiver presentations to organizations interested in central receiver commercialization.
SN	January, 1991	IB	Complete technical evaluation of Dish/Stirling Joint Venture responses to request for proposal.
SN	January, 1991	IC	Begin identification of R&D necessary to reduce commercial parabolic trough solar electric plant operation and maintenance costs.
SN	March, 1991	ID	Participate in the SOLTECH 91 joint meeting.
SN	January, 1991	IIA2	Task 3 conceptual design review for the single-element SM dish project.
SN	February, 1991	IIB1	Complete final report on molten salt transport loop testing.

SN	March, 1991	IIB1	Complete volumetric receiver absorber material characterization testing.
RE	January, 1991	IIB2	Initiate Cummins/Thermacore heat-pipe receiver durability testing.
SN	February, 1991	IIB3	Complete evaluation of the Sandia tube/screen-wick gas-fired evaporator.
SN	March, 1991	IIB3	Complete final design of the Stirling Technology Company ASCS.

Fourth quarter, FY 1991

RE	March, 1991	IIA3	Propose most promising solutions for delamination problem in film.
RE	July, 1991	IIA3	Document investigation of alternate reflector materials.
SN	April, 1991	IB	Award contract(s) for Dish/Stirling Joint Ventures.
SN	April, 1991	IIB1	Conclude coordination of the final report on USA/FRG, second-generation central receiver study.
SN	May, 1991	IIB1	Issue status report on PRE salt flow and low-level solar characterization testing.
SN	May, 1991	IIB2	Complete short-term, bench-scale, pool-boiler testing to finalize design parameters for second-generation full-scale pool-boiler.
SN	May, 1991	IIB3	Complete preliminary design of the Cummins/Sunpower/Thermacore ASCS.

Fourth Quarter, FY 1991

SN	September, 1991	IA	Present a letter report to DOE summarizing the results of interactions with outside organizations or central receivers.
SN	September, 1991	IC	Finalize operational maintenance cost-reduction plan for commercial parabolic trough solar electric power plants.
SN	September, 1991	IIA1	Completion of testing and documentation of two large-area, glass-mirror heliostats and low-cost drive.
SN	September, 1991	IIA3	Document field replaceable reflector material results.
SN	September, 1991	IIB2	Initiate long-term, pool-boiler, bench testing to assess lifetime issues.

SN	September, 1991	IIB2	Complete installation and checkout and initiate on-sun testing of the next-generation, pool-boiler receiver.

SIGNIFICANT ACCOMPLISHMENTS SUMMARY

MAJOR MILESTONES	Planned	Actual
FY 1991		
TASK I		
• Issue request for proposal for Dish/Stirling Joint Venture.	10/90	10/90
• Make utility-scale central receiver presentation to review committee.	12/90	12/90
• Complete technical evaluation of Dish/Stirling Joint Venture responses to request for proposal.	01/91	01/91
• Begin identification of R&D necessary to reduce commercial, parabolic trough, solar electric plant operation and maintenance costs.	01/91	06/91
• Initiate utility scale central receiver presentations to organizations interested in central receiver commercialization.	02/91	12/90
• Participate in the SOLTECH 91 joint meeting.	03/91	03/91
• Award contract(s) for Dish/Stirling Joint Ventures.	04/91	05/91
• Present a letter report to DOE summarizing the results of interactions with outside organizations on central receivers.	09/91	04/91
• Finalize operational maintenance, cost-reduction plan for commercial, parabolic trough, solar electric power plants.	09/91	
TASK II		
• Complete testing of the 7-meter diameter SM optical element.	11/90	06/91
• Phase 1 design review for the faceted dish project.	11/90	11/90
• SAIC completes fabrication of a prototype of its 100-m^2 market-ready heliostat.	11/90	11/90
• SKI completes a design for its market-ready heliostat.	11/90	11/90
• Complete Task 3 conceptual design of simple element dish.	01/91	03/91

SIGNIFICANT ACCOMPLISHMENTS SUMMARY (cont'd)

MAJOR MILESTONES	Planned	Actual
FY 1991		
• Initiate Cummins/Thermacore heat-pipe receiver durability testing.	01/91	02/91
• Task 3 conceptual design review for the single-element SM dish project.	01/91	03/91
• Complete final report on molten salt transport loop testing.	02/91	03/91
• Complete evaluation of the Sandia tube/screen-wick gas-fired evaporator.	02/91	02/91
• Propose most promising solutions for delamination problem in film.	03/91	03/91
• Complete volumetric receiver absorber material characterization testing.	03/91	05/91
• Complete final design of the Stirling Technology Company ASCS.	03/91	03/91
• Conclude coordination of the final report on USA/FRG second generation study.	04/91	08/91
• Complete short-term, bench-scale, pool-boiler testing to finalize design parameters for second-generation full-scale pool-boiler.	05/91	
• Issue status report on PRE salt flow and low-level solar characterization testing.	05/91	
• Complete preliminary design of the Cummins/Sunpower/Thermacore ASCS.	05/91	04/91
• Document investigation of alternate reflector materials.	06/91	09/91
• Completion of testing and documentation of two large-area glass-mirror heliostats and low-cost drive.	09/91	
• Complete installation and checkout and initiate on-sun testing of the next-generation pool-boiler receiver.	09/91	
• Initiate long-term, pool-boiler, bench testing to assess lifetime issues.	09/91	
• Document field replaceable reflector material results.	09/91	09/91

TECHNICAL STATUS REPORT

I COMMERCIAL APPLICATIONS

A. Central Receiver Cooperative Projects

Objective: Develop and support an implementation plan for a utility-scale solar central receiver electricity generating facility.

Accomplishments:

Southern California Edison Company forming consortium for Solar Two.

The principal activity at this time on the Solar Two project is the effort to secure commitments for the 50% cost share from the utility sector as mandated by DOE. The solicitation effort is being led by Southern California Edison, with support from Sandia, Bechtel, and the two other committed utilities, Sacramento Municipal and the Los Angeles Department of Water and Power. The goal is to raise the required $19.5 million by early FY92. SCE held a workshop on the Solar Two project on August 8 in Albuquerque; representatives of 14 utilities, NREL, (formerly SERI) the Bureau of Reclamation, the California Energy Commission, the Arizona Energy Office, EPRI, PNL, DOE/OSEC and the Texas Energy Management Center attended. As a follow-up to the workshop, SCE is visiting individual utilities to directly solicit their participation in the project. At the end of the quarter, Idaho Power had been visited and reacted very favorably to the project. Visits to Arizona Public Service, Salt River Project, Tucson Electric, PG&E, Southern California Public Power Administration, EPRI, the Southcoast Air Quality Management District, PacifiCorp, PNM, Nevada Power, Sierra Pacific Power, City of Austin, and the Lower Colorado River Authority will be arranged early next quarter. At this time, many utilities have expressed interest in participating in the project, and many will use EPRI "tailored collaborations" to supplement their contribution. Contributions from the industrial sector are also being solicited. However, there have been no further firm commitments to the project.

Meeting with the California Energy Commission.

On September 9, Southern California Edison's VP, R. Dietch, met with the Chairman of the California Energy Commission, Charles Imbrecht and Commissioner A. Kevorkian to discuss SCE's plans for the Solar Two project and to directly request financial support from the State. DOE was represented by Sandia at the meeting. Chairman Imbrecht was very supportive of the project,

and indicated he would personally spearhead an effort in the State Legislature to appropriate funds from California's 1991 allotment of the Petroleum Violation Escrow Account. The California Legislature is expected to complete appropriation of these funds in January 1992.

Nationwide press release on Solar Two.

The Southern California Edison Co., the Los Angeles Department of Water and Power, and the Sacramento Municipal Utility District jointly announced publicly their intention to convert the Solar One Pilot Plant to an experimental solar power tower with a nitrate-salt heat-transfer and thermal storage medium. The proposed partnership between the utilities and DOE was prominently featured in the press release. The story was picked up by a number of newspapers, including the Los Angeles Times, the New York Times, the Wall Street Journal, USA Today, and the Sacramento Bee. In addition, there was extensive coverage in the electronic media, including CNN. A copy of the newspaper articles and the utilities' press kit has been provided to DOE/OSEC.

Contract placed with Mike Lotker to review barriers to Solar Energy commercialization.

A contract has been placed with Luz's Mike Lotker to prepare a short report summarizing his experience with marketing a solar thermal technology. The Luz experience should provide some unique insights that will be useful in the future marketing of commercial central-station solar power plants, both solar thermal and PV. The report will focus on the barriers to commercialization, including such topics as PURPA regulations, tax policy and frequent expiration of tax credits, the possible impact of a renewable energy production incentive, the lack of incentives to utilities (both IOU and municipal), state regulation of utilities, including the impact of environmental adders, and the need for leadership on a national scale. A first draft of the report should be completed by early next quarter.

Central receiver briefings.

In support of SCE's efforts to form the consortium to convert the Solar One Pilot plant to an advanced cycle using molten salt, technical briefings were given to several additional organizations this quarter. On July 16, a briefing was given to personnel of Public Service of New Mexico in Albuquerque and on September 27, a meeting was hosted by the Utah Energy Division in Salt Lake City. The latter briefing was attended by two of the three commissioners of the Public Service Commission as well as representatives of PacifiCorp (Utah Power). In FY91, briefings on solar power towers were given to nearly every utility, state regulatory agency and public utility commission in the West. The information

obtained from these interactions will be vital to the future commercialization of solar power towers.

Workshop on utility applications of solar energy.

On August 5, the State of Nevada sponsored a one-day workshop on solar technologies for utility applications. Presentations were made by the Director of the State Energy Office, a Commissioner of the Public Service Commission, the Nevada Power Company, the Sierra Pacific Power Co., and Sandia. The workshop was attended by nearly 40 individuals, including staffers from Nevada's Congressional Delegation and reporters from Nevada's most important newspapers and TV and radio stations. The state energy office described Nevada's interest in renewable technologies and the present bad perception of DOE within the state because of NTS and Yucca Mountain ("DOE is DOA in Nevada"); the concept of a solar power park in Nevada could be very appealing. Commissioner Rose McKinney-James described Nevada's new regulations that incorporate societal costs into the selection of a utility's new generating options, and the state's two largest utilities described their current activities concerning renewable technologies, including photovoltaics, solar thermal, and geothermal. Sandia's representatives described the current state of solar thermal technologies and summarized Southern California Edison's plans to restart Solar One with a molten-salt heat transfer system. Both of Nevada's large utilities are interested in the project and could provide financial support.

Initiated a study to resolve the thermal storage and steam generator design, cost and warranty issues.

In support of the Solar Two project, an RFP was sent out for bid this past quarter to initiate a study to resolve issues related to the design, fabrication, cost and warranty of molten salt thermal storage systems and salt/steam generator designs for molten salt solar central receiver power plants. In order to select a design for the Solar Two project (a retrofit of the Solar One pilot plant with molten salt technology), an optimal design for a 100 MW_e plant needs to be defined. The Utility Studies, completed in 1988, proposed a baseline design for all the major subsystems in a central receiver power plant. However, the thermal storage and steam generator are two subsystems that need further definition. The RFP that was prepared and sent out to prospective bidders will address these two subsystems, the study is expected to last six months.

In resolving the thermal storage issues, the contractor will evaluate three basic designs for the molten salt hot tank, one internally insulated and two externally insulated. (Design of the "cold salt" tank is straight forward and is well defined in the Utility Studies.) The contractor will solicit information (e.g., design issues, cost, and warranty information) from the companies who proposed the storage designs in the past and compare and evaluate them. Recommendations will be

provided on which system(s) are optimal for a 100 MW plant and how the system can be modeled in the Solar Two project.

The issues related to the steam generator involve more of a comparison of the systems available and their applicability to a 100 MW system rather than specific design issues. The three systems being evaluated are a U-tube/U-shell design, a straight tube/straight shell design, and a kettle boiler type design. The study will evaluate the design, cost and warranty of all these systems for a 100 MW plant. This study will aid in selecting the system for the 100 MW plant and the system that will need to be modeled in the Solar Two design.

The RFP has been sent out and bids are due back at Sandia on October 7, at which time they will be evaluated and a contractor selected.

Inspection of the molten salt cold pump completed.

At the request of Southern California Edison, the cold pump was removed from the pump and valve loop and sent back to the manufacturer (BWIP) for tear-down and inspection. The pump was operated for over 2400 hours. The only problems associated with its operation were related to the motor. However, questions have been raised about the cold pump reliability during discussions of the Solar Two project.

On September 12, representatives from Bechtel, Southern California Edison, Sandia and BWIP met to inspect the disassembled pump and discuss the posttest inspection results. The inspection showed the pump to be in very good condition. The impeller wear rings showed evidence of erosion, although this is not a major concern. However, the bearings, which were the primary concern, appeared to be in good condition. The only suggested modification was to make the impeller wear rings out of harder material to reduce erosion.

Much of the meeting was spent discussing the motor problems and their association with the pump. There are methods to resolve the shaft upthrust which was experienced early in the test program, so this is not a concern.

The pump will be reassembled, without modifications, and sent back to Sandia for possible future tests.

<u>Planned activities next quarter</u>

- Continue support of SCE's efforts to form a Solar Two consortium of utilities and regulatory agencies.

- Continue technical support of SCE's efforts to define the design of Solar Two that best simulates a commercial plant.

- Select contractor for the thermal storage and steam generator study and initiate study.

- Reinstall the cold pump for possible future testing.

B. Dish/Engine Cooperative Projects

Objective: Form one or more industry, user and government consortia which will then begin efforts to field economically competitive prototype dish/Stirling solar electric systems for remote markets within the next three years.

Accomplishments

Cummins Power Generation awarded contract for Dish-Stirling Joint Venture Program.

The Sandia Dish-Stirling Joint Venture Program (JVP) contract was awarded to Cummins Power Generation on September 9, 1991. Cummins has been performing limited work on this program under a letter contract in effect since May 31, 1991.

The objective of the Dish-Stirling Joint Venture Program is to field economically competitive dish-Stirling systems for remote power markets within the next three years. The technical evaluation committee selected CPG from the four responsive proposals, because (1) CPG had the highest level of cost sharing, (2) CPG had the most experience with integrating systems, (3) CPG had the best understanding of the markets, and (4) CPG was the only respondent clearly committed to commercialization.

In the Dish-Stirling Joint Venture Program, CPG plans to field three generations of 5-kW_e systems. The first (prototype) systems will demonstrate water pumping and village power applications at the Abilene, Texas and California Polytechnic University test sites. In Phase 2, "design validation" water pumping and village electrification modules will be developed and fielded. In Phase 3, a total of ten "manufacturing validation" modules will be built. Georgia Power, AT&T (Phoenix), Hawaii Electric, and PG&E have agreed to host tests and to provide all of the installation and test support costs. The total program is expected to cost approximately $14M (not including Sandia and NREL technical contributions) over a three-year period with CPG and its industrial partners providing approximately 50% cost share.

During the period of the Sandia Dish-Stirling Joint Venture Program (JVP) letter contract to Cummins Power Generation (CPG), since June 1991, significant

improvements in technology, primarily focused on reliability, have been made. The CPG/Sandia emphasis in the JVP is reliability.

Sunpower implements gas bearings.

Sunpower, Inc. demonstrated gas bearings on the CPG 5-kW_e free-piston Stirling engine. The cost of implementing this life-extending modification was entirely supported by Sunpower. Another Stirling machine developed under another program which utilizes gas bearings, is currently undergoing life testing with encouraging results. Sunpower, however, has not yet achieved the engine/alternator performance specifications of 6 kW_e net output.

Parallel Stirling engine development included in Joint Venture Program.

Because of the importance of the Stirling engine to the Joint Venture program, Clever Fellows Innovation Consortium (CFIC) was included as a parallel Stirling engine developer. The CFIC engine technology, which utilizes flexures, virtually eliminates wear and makes possible extremely long-life engines. CFIC is confident enough in the technology that they were willing to accept a fixed-price contract for a firm-date delivery of an engine that meets the CPG specifications. CPG will select either the Sunpower or CFIC engine for further development in Phase 2 of the JVP. CFIC provides additional Stirling engine expertise and technology to CPG. CPG will procure, manufacture, and test all engines in phases 2 and 3. CFIC and CPG are still negotiating royalty agreements and have, therefore, performed a limited amount of work under this program.

Thermacore completes on-sun durability heat-pipe receiver testing.

Thermacore, Inc. completed 366 hours of on-sun testing of a reflux heat-pipe receiver. This NREL supported work of a 4^{th}-generation design has provided a good foundation for a 5^{th}-generation design to be evaluated on-sun under the Joint Venture Program. A design review was held at the Thermacore facility on September 10 with representatives from Sandia, CPG, NREL, and Haynes International in attendance.

Silk screen techniques investigated for stretched-membrane facets.

CPG, South, formerly LaJet personnel, investigated and implemented in tests, techniques utilized in the silk screen industry to fabricate stretched-membrane facets. The approach appears to produce a higher-quality facet, at a lower cost, and with potentially less long-term degradation than the previous technique. Substantial progress related to the rim design and film attachment has also been made.

Contracts placed for concentrator drives.

Contracts were placed with Peerless-Winsmith and A&A Systems to design and fabricate the diurnal and declination drives, respectively, for the CPG-460 solar concentrator.

Cummins Electronics continued concentrator/engine controls integration.

Cummins Electronics (CEL) continued integration of concentrator and engine controls. All controls and sensors used in the system are now the responsibility of CEL and will be implemented utilizing the same demanding total quality management principles used in state-of-the-art, diesel-engine, electronic-control systems.

Sandia provides equipment for the Dish-Stirling Joint Venture Program.

As a consequence of the elimination of LaJet Energy Company as a subcontractor in the JVP, (a business decision by CPG fully supported by Sandia) many of the solar specific assets owned by LaJet are no longer available. Consequently, Sandia loaned a LEC-460 solar concentrator to CPG, South. It will be used to develop manufacturing fixtures for concentrators fabricated in Phase 1, and to test the next-generation durability heat-pipe receiver. The controllers developed for the LaJet Innovative concentrator, and stretched-membrane facets, have also been provided.

Sandia provides technical support for the Dish-Stirling Joint Venture Program.

Sandia provided to CPG recommended design modifications to the Thermacore receiver geometry that will significantly reduce peak flux intensities on the heat-pipe absorber. The flux intensities and performance implications of the modifications were quantified with the Sandia-developed receiver analysis models, CIRCE2 and AEETES. CPG plans to implement the modifications.

The SAND report "The Solartrak Solar Array Tracking Controller" by Alex Maish (SAND90-1471), was provided to CPG and CEL. If possible, the hardware developed in the Photovoltaic program will be used in the JVP. Alex has agreed to provide technical guidance to the JVP controls development.

Planned Activities for Next Quarter

- A kick-off meeting for the JVP will be held October 23, 1991 in Columbus, Indiana. Program planning will be the focus of the meeting.

- CPG, South will move into a new facility in Abilene, Texas. The city of Abilene, as part of their commercial development program, has offered Cummins a facility, including a test site, at an extremely competitive rate.

- Sandia will provide technical support in the following areas: loan of calibrated reflectometers, loan of a direct normal insolation pyrheliometer, loan of a video flux mapper system, loan of surplus computers for site data acquisition. Sandia personnel and training, will also be provided as necessary.

- Sunpower will demonstrate full-power output (6 kW_e) of their prototype solar engine.

- A draft request for proposal (RFP) for a utility-scale dish-electric joint venture program will be completed.

C. Parabolic trough cooperative projects

Objective: Work closely with industry to reduce the costs associated with operating and maintaining parabolic trough-based, solar electric, generating plants through research and development based on the extensive operating experience of LUZ Engineering Corporation.

Accomplishments:

Draft report completed which summarized historical operating and maintenance costs at SEGS plants.

Despite the current financial dilemma of LUZ International, Sandia is continuing our contract with LUZ Engineering Corporation (LEC) to reduce the operating and maintenance costs at SEGS plants. Since LEC, a subsidiary of LUZ International, is paid by revenue sales from the plants and by the plant owners, this company, or a derivative from it, will continue to operate and maintain the SEGS plants. It is unclear whether LUZ will file bankruptcy, but if it occurs, it appears Chapter 11 will be sought rather than Chapter 7.

The costs associated with O&M have a significant influence on the economic viability of the SEGS technology. Currently, O&M costs account for approximately 20% of the plant electricity costs. Reductions in O&M costs would enhance the marketability, further development, and widespread use of SEGS technology, as well as other solar power technologies currently being developed by DOE. An example of a DOE technology that would benefit is solar central receivers. Central receiver power plants have many of the same subsystems contained within a SEGS power plant and the O&M of these subsystems would be similar.

This work will be performed in two phases, each governed by a separate subcontract:

1. A study of the historical O&M costs at the LUZ plants is conducted and these costs are categorized. This information is used to develop a multi-year strategy to reduce the cost of the most costly O&M categories. Upon completion of the strategy, research and development (R&D) is begun to reduce the cost of one of the more important O&M categories.

2. The full multi-year strategy developed in Phase 1 is implemented. Work will be performed to complete the R&D begun in Phase 1 and on the remaining important O&M categories.

The Phase 1 contract is underway and the work was scheduled over a 6-month period. This work is entirely funded by DOE.

Phase 2 is to last several years and the cost share between LUZ and DOE is 50% by each organization. Sandia will begin negotiating this new contract about midway through Phase 1.

Because of distractions caused by LUZ's financial dilemma, our contract with LEC to reduce O&M costs is approximately two months behind our original schedule for Phase 1. During the quarter, LEC wrote a draft report which summarizes historical O&M costs. The report has been reviewed to assure that all O&M costs incurred at the plants are properly accounted. The report also includes a list of potential cost-reduction categories. This list is currently being evaluated to determine the most cost-effective categories for subsequent joint work. A meeting is scheduled for early next quarter to discuss the results of the evaluation. At that time, we should know how many R&D dollars will be required from DOE and LUZ to implement Phase 2. The LUZ cost share will come from the owners of the SEGS plants and it is not assured that the owners will approve the expenditure. The owners need to be sold on the potential benefits of this program.

Workshop held commercializing Solar Thermal Electric Technology

A workshop on the issues involved in developing commercial Solar Thermal Electric technologies was held at NREL on September 25, 1991. Invited speakers were Dave Kearney (former vice president of Advanced Technology Development at LUZ) and Michael Lotker (former vice president of Business Development at LUZ). Issues covered in the workshop were a review of the hurdles faced by LUZ in developing projects, the current economic viability of solar thermal technologies, problems associated with making technological improvements in the private sector, and recommended critical activities for DOE

laboratories to help industry in commercializing technologies. While a number of issues were discussed at length in the workshop, some of the key points related to the commercialization process were the need for a stable set of policies and incentives toward solar thermal technology, the need for a strong market pull, the need for system integrator companies (such as LUZ), and eliminating perceived risks for the owners of the plants.

Planned activities next quarter

- Develop an estimate of the financial support needed from DOE and LUZ to perform multi-year O&M cost reduction program. Document this in a report.

- Brief SEGS owners on the benefits of this program and begin to obtain financial commitment from them for the second phase of this program.

- Begin testing to reduce cost on at least one O&M category.

D. Design Assistance

Objective: Accelerate the use of solar thermal systems through cooperative efforts with private industry, by assisting and educating potential users, and by supporting industry and users in the selection, design, characterization, and demonstration of promising solar thermal systems.

Support: The Design Assistance Center activities reported here are supported by (1) the Solar Thermal Electric Program, (2) the Solar Thermal Industrial Program, or (3) both programs. They are reported together for completeness and in recognition of the fact that boundaries are often not distinct within each activity.

Accomplishments:

Sandia continues support to Gould Incorporated, Foil Division.

Based on a three-month evaluation, Gould plans to upgrade its 60,000 square foot solar system that is used to produce hot water for a copper foil manufacturing process. The upgrade should be completed within a year or two and, when completed, is expected to produce electricity savings of at least $120,000 per year. The DOE program, as represented by Sandia, will continue to assist throughout the course of the project.

Solar electric feasibility study for Plains Electric.

DOE, represented by Sandia personnel, have completed a feasibility study for Plains Electric Cooperative in Albuquerque, New Mexico. The purpose of the study was to determine the cost-effectiveness of using a solar thermal system at one of Plains' existing facilities. Plains' officials expect a load growth of approximately 3% per year and the options for providing this power are through a power purchase from the local utility or restarting a 45 MW gas/oil plant located at Algodones, New Mexico. The Algodones plant is currently in an operational stand-by status.

The study concluded that a solar retrofit using dish or trough technology would be technically feasible. However, Plains' current long-term and very favorable natural gas purchase agreement coupled with the small scale of the application negated any potential cost benefit.

Technical consulting for the California Energy Commission (CEC).

The DOE's representatives at Sandia Labs are involved in a number of CEC activities. The first involves the proposed solar project at the prison in San Luis Obispo. Sandia engineers consulted on the proposal evaluations and are now involved in preparing to install performance monitoring equipment for the third-party financed system from Besi Corporation.

A second activity relates to another CEC proposed project. Discussions were held with CEC, CDC and the Sacramento Municipal Utility District (SMUD) regarding solar powered cooling at the Galt, California correctional facility. The discussions verified SMUD's interest in working with the DOE to co-fund, design and build a solar absorption system at Galt. Further, SMUD is interested in working on a longer term effort to develop resources to more effectively use solar thermal technology for utility demand side-management efforts.

A third activity also involves solar steam and water heating. A tour of the five California prison facilities was made in order to assess the appropriateness of installing such systems at that site. Preliminary indicators are favorable for all of the sites. New RFPs are expected within the next quarter.

Technical support for the New Mexico State Energy and Minerals Department (NMEMD).

The DOE, represented by Sandia, is continuing to work with the NMEMD to provide technical assistance and consulting regarding the use of solar thermal technology in the state of New Mexico. Activities include solar thermal technology workshops for NMEMD staff, assistance in developing a comprehensive energy policy, and technical assistance in developing a

methodology to identify solar thermal projects within state institutions. The DOE PV and ST programs, as represented by Sandia's ST and PV design assistance centers, are providing collaborative assistance where appropriate.

Solar thermal technology applied at Kirtland Air Force Base.

The DOE, represented by Sandia, is assisting the USAF in two solar energy projects on Kirtland AFB near Albuquerque, New Mexico. The first project involves technical assistance to the Air Force in procuring and installing a solar system to augment the steam boiler at the East Officer's club on Kirtland AFB. The assistance involves providing the Air Force with technical information regarding the economics of solar thermal technology. This information is planned for use in justifying the planned procurement of a third-party financed solar system for the club. The procurement package will be based on one that was used by the CEC in the San Luis Obispo project and is expected to be released before the end of this year. The DOE program will provide technical consulting to the Air Force throughout the procurement process.

A second effort involves assistance to a Kirtland AFB Architect & Engineering (A&E) Company that was hired to renovate over 100 of the base houses. The DOE, through Sandia, will provide several services to the A&E firm including: 1) training regarding solar water heating technology, 2) develop and help apply a procedure that allows the architects to identify those houses that are best suited for solar water heating, 3) assistance in writing the RFP package to procure the contractors for installing the solar systems, and 4) technical consulting during the installation and initial operation of the systems. This effort is expected to start in 1992 and will continue for about six months.

Refurbishment of solar system at the VA Hospital.

The DOE, through Sandia, has agreed to assist the Veterans Administration Hospital in Albuquerque, New Mexico to renovate and to return an existing solar system into service. This system, which was installed in 1985, has been shut down since around 1986 because it produced excessively hot water and caused pressure/temperature relief valves to open. The hospital is now interested in using the system to help it meet new federal institution energy reduction goals that were recently mandated by President Bush (Executive Order 12759).

DOE engineers at Sandia begun working with VA engineers to restart the system. One-half of the system is operational now and it is anticipated that the full system could be placed back into service by the end of fall 1991. After it is operational, Sandia's DOE engineers estimate that the system could save about $12,000 per year in gas usage.

Design assistance to Stirling Thermal Motors (STM).

DOE engineers at Sandia continued work with STM to design a pressure hull and oil sump for the solar version of the STM Stirling engine. STM is currently developing engineering drawings of the new designs. It is expected that Sandia will provide finite element analysis of the new design for the pressure hull to be used for on-sun testing.

Testing of the Energy Concepts Ice Maker

The DOE, as represented by Sandia engineers, is continuing to work with Energy Concepts to test the Mini-Isaac solar ice maker. The testing has followed a plan that was jointly developed by DOE and Energy Concepts. The results of the tests are being used by Energy Concepts to improve the design of the system. Testing is expected to continue through the next two quarters.

Testing of the BSAR solar distiller.

The DOE program, through Sandia, has begun testing the residential solar distiller developed by BSAR. The testing is based on a plan that was jointly developed by DOE and BSAR. The test results will be used by BSAR to improve the design of the system. Testing is expected to continue through spring of 1992.

Solar message is presented.

Representatives of DOE at Sandia Labs have presented various solar talks. These are outlined below:

a) Workshop on Solar Two. Southern California Edison Company, together with Sacramento Municipal Utility District and the Los Angeles Department of Water and Power, hosted a workshop for utilities interested in central receivers. Representatives of fourteen utilities attended. Presentations centered on Solar Two, the proposed retrofit of the Solar One plant, with a molten-salt system. Other talks focused on the status of the technology.

Engineers from DOE's Sandia Laboratories made presentations about technological readiness. Utility supporters showed that when environmental costs are factored in, central receivers are competitive with conventional generators. The goal of Solar Two is to demonstrate that a commercial size central receiver can produce electricity competitively and reliably.

b) NM Solar Conference. The New Mexico land Office sponsored a conference in August on using alternative energy, concentrating on how the state can use alternative sources of energy -- particularly solar. The DOE, represented by Sandia, made presentations about the use of solar thermal technology. The Land Office has asked for DOE to consult about the development of a renewable energy park near Albuquerque.

c) In early September, the DOE engineers at Sandia were invited to address the Southwest Energy Council, an organization of legislators from nine energy producing states, about solar energy technology and tax credits. Special emphasis was placed on the efforts in California and Nevada to incorporate the costs of combustion by-products into the estimates for new fossil fuel electric generating plants. The talk was well received and indications are that some of the states may ask for technical assistance from DOE's Sandia Laboratory in developing similar strategy.

d) The DOE, as represented by Sandia engineers, were invited to help the Air Force identify possible solar energy applications on some Strategic Air Command bases. The Sandia engineers made a presentation about solar technology and then monitored a discussion about the solar potential within specific bases. March AFB in California was selected as a prime candidate for using solar thermal technology to offset high peak electricity rates. The USAF may ask the DOE to assist in the development of a project at that site.

Miscellaneous Consulting Efforts

Other on-going technical assistance projects include:

- LBJ Hospital in Samoa
- New Mexico Solar Energy Industries Assoc.
- Solar Weatherization Assistance Program
- Utah Parks and Recreation Dept.
- Pennsylvania Energy Office

On-going test and evaluation projects include:

- Sunsteam
- IST

Significant progress on these activities will be reported next quarter.

Planned activities next quarter:

- Current plans are to continue to provide direct technical support to those organizations with which they are currently working. Accelerated efforts are planned to identify other opportunities to provide this service and other technology transfer and outreach activities. One of the potential areas is the Federal government, which has significant potential for use of solar thermal electric technology. Another effort will involve development of state energy offices to encourage the development of solar thermal technology within state institutions.

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	Al Heckes	TOPS
	Adm. Watkins' Off	Solar materials for school visit with the First Lady, Barbara Bush
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NREL Industrial Contacts

Industrial Contacts on Optical Materials

CONTACT	ORGANIZATION	COMMENTS
T. Evans and W. Schrenk	Dow Chemical	Alternate reflector materials
F. Wilkinson	Integrity	Aluminum reflectors systems
D. Dahlen	3M Company	Optical measurements of outdoor samples from Phoenix and Miami
K. May and R. Gee	1ST	Alternate reflector materials
S. Levy	DuPont	Alternate reflector materials
M. McGlaun	Cummins Power	Alternate reflector materials
B. Klein and D. Nick	Business Factors, Inc.	Alternate reflector materials
P. Johnson	Rohm & Haas	Alternate reflector materials
J. Blackmon and materials	McDonnell-	Alternate reflector
K. Stone	Douglas	
P. Arbogast	North American Sun	Alternate reflector materials Inc.
K. H. Funken	DLR, Germany	Holograph reflectors
W. Meinecke	DLR, Germany	and polymer mirrors
P. Gero	SRS	Alternate reflector Technologiesmaterials

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Eric Brus	World Information	General technology
Nancy Rader	Systems information	Near-term technology information

II TECHNOLOGY DEVELOPMENT

A. Concentrator Development

1. Heliostats

Objective: Establish commercial readiness of the heliostat for central receiver solar thermal electric applications.

Accomplishments:

Initial evaluation of SAIC's Dual-Module Membrane Heliostat.

Initial tests to confirm the operational capabilities of Science Applications' 100-m^2 dual-module stretched-membrane heliostats were performed. Movement of the heliostat from stow to tracking, tracking to stow, and tracking the sun were evaluated. The automatic focusing system was also evaluated. Minor problems were identified in all areas, and SAIC has been asked to correct them. In addition, SAIC will cant the heliostat's two mirror modules. Evaluation of the optical quality of the heliostat will begin next quarter.

Detailed beam quality measurements performed on ATS's 150-m^2 heliostat.

A detailed analysis of the beam quality and tracking accuracy of Advanced Thermal Systems' 150-m^2 glass heliostat were completed. The heliostat generally meets all specifications. Comparable testing of SPECO's 200-m^2 heliostat is still underway.

Planned activities next quarter

- Testing and evaluation of SPECO's 200-m^2 heliostat, ATS's 150-m^2 heliostat, and Winsmith's low-cost heliostat drive will continue
- Testing and evaluation of SAIC's 100-m^2 stretched-membrane heliostat will continue.

2. Parabolic Dishes

Objective: To bring parabolic dish concentrator technology to technical readiness for use in dish/Stirling electric.

Accomplishments:

Proposals for the fabrication of facets for the Faceted Stretched-Membrane Dish Project evaluated.

Proposals for the fabrication of facets for the Faceted Stretched-Membrane Dish have been received and evaluated by a joint Sandia-NREL Technical Review Panel. Negotiations are currently under way with two companies. A contract(s) should be placed in October.

Request for Quotation for fabrication of the drive pedestal and support structure for the Faceted Stretched-Membrane Dish developed.

A Request for Quotation for the fabrication of the drive pedestal and support structure for the Faceted Stretched-Membrane Dish has been developed. It will be released in late November after the drive pedestal design has been completed.

Drive design for the Single-Element Stretched-Membrane Dish finalized.

Solar Kinetics, Peerless-Winsmith, and Sandia have completed their evaluation of the drive design for the Single-Element Stretched-Membrane Dish. Calculations show that a modified version of the low-cost drive, which was developed for the heliostat program, will carry the loads of the Single-Element SM Dish. This approach has been adopted in the design.

Solar Kinetics and Sandia have also determined that an off-the-shelf tracking control system will be used for the Single-Element SM Dish. Two candidates are being evaluated and the choice will be made within the next month.

Test Bed Concentrators (TBC) upgraded.

The two test bed concentrators used for engine and receiver testing, TBC-1 and TBC-2, have been recently re-plumbed for cooling. The new cooling system was designed to handle the full power from both TBCs simultaneously. Both concentrators have also been re-plumbed for calorimeter plumbing, which uses a once-through system. Both plumbing systems were designed to accommodate new ES&H standards, including hard piping (wherever possible) to reduce the possibility of a leak, secondary containment for the water/glycol, and stainless-steel tubing for the compressed gas system.

Several other improvements to the TBCs have been completed in the last month. Improvements in the plumbing for the air-drive motor were implemented. Several ES&H items related to the TBCs were completed. These included new guards around the elevation drive couplings, new gages for the compressed air system, and hand rails for the step-over between the two dishes.

Finally, some mirror refurbishment has been completed on TBC-1. During the last few years, many of the mirror surfaces have degraded (due to the sulfur in the Foamglass substrate corroding the silver) or have been damaged. The most severely corroded or damaged facets were noted and replaced. A nighttime alignment of the new facets, along with minor adjustments to over 100 facets, was performed at the beginning of October. The alignment technique used consisted of using a distant light source and a target board mounted near the focal point of the dish. Each facet was adjusted until the return image matched the pre-determined image outline on the target board. Figure 1 is a photo of the target board following the alignment.

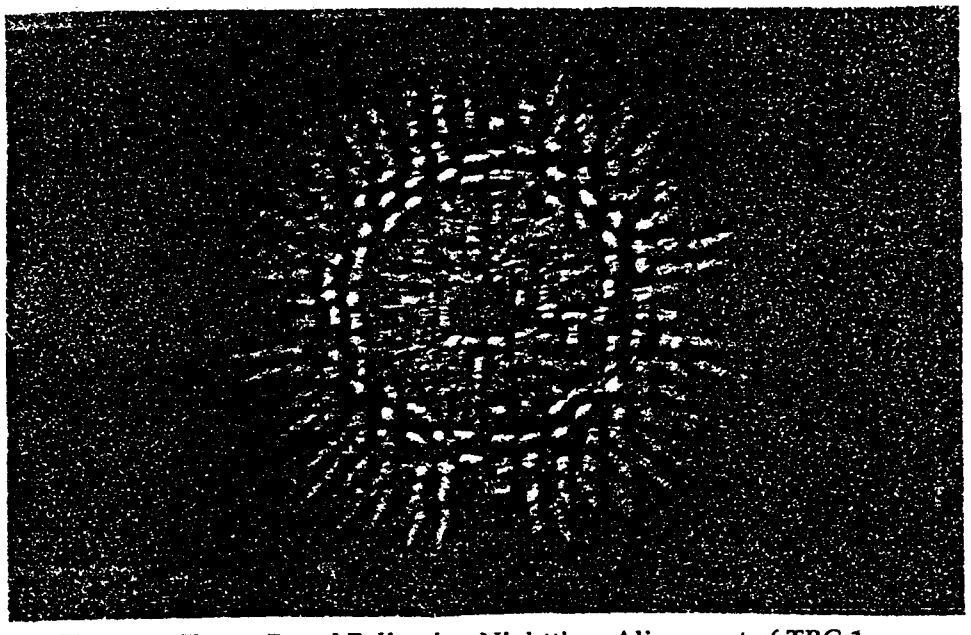

Figure 1 - Target Board Following Nighttime Alignment of TBC-1.

Preparations are underway for cold-water calorimetry on TBC-1.

Planned activities next quarter:

- Place contracts for the fabrication of facets for the Faceted Stretched-Membrane Dish.
- Complete design of the drive pedestal and support structure for the Faceted Stretched-Membrane Dish.
- Release a Request for Quotation for the fabrication of the drive pedestal and support structure for the Faceted Stretched-Membrane Dish.
- Prepare a plan for a test program to validate molten salt component design in support of the validation plant.
- Prepare a proposal, with CIEMAT (Spanish) for testing the internal film receiver at the Plataforma Solar de Almeria. This is contingent on CIEMAT's agreement to participate.
- Initiate a contract with Bechtel for design and fabrication of a volumetric receiver absorber to be tested at the Plataforma Solar. This activity is contingent on the approval of the IEA/SSPS to test the absorber.
- Initiate testing of volumetric receiver absorber materials at New Mexico State University. Wire mesh materials will be tested to support the Bechtel absorber design.

3. Optical Materials

Objective: Perform appropriate R&D to obtain materials for concentrators which have improved durability and performance, increased service lifetimes, and decreased cost.

Accomplishments:

Accelerated tunnel tests continue at NREL for samples mounted on curved substrates.

Recent results at NREL suggest that thermally treating samples of ECP-305 after they have been curved (single-axis) can provide substantial resistance to delamination of the silver layer from the polymer film, even for extreme curvatures (~14 inches, radius of curvature, R). However, for such curvatures, thermal treatment prior to bending is ineffective. An experiment is underway to investigate whether thermal treatment before bending is useful for more realistic curvatures (R~70 inches). Eleven such samples have been under test for 47 days, and no tunnel failures have been experienced.

Improved procedures in delamination resistant identified in accelerated tunnel tests are being investigated in an outdoor exposure.

A new set of samples has been experiencing outdoor tunnelling tests for approximately 1.5 months. The intent is to demonstrate improved resistance to delamination in an outdoor environment for certain constructions which were identified in the accelerated tests on static and cyclic water immersion. Samples include sputtered silver reflectors without edge tape, ECP-305 with Tedlar edge tape, and thermally treated ECP-305 without edge tape. A duplicate set of two samples each were purposely damaged (by drill holes, hammer blows, and razor cuts) prior to exposure. After approximately 1.5 months of exposure, all such damaged samples had experienced tunnel failure with the notable exception of the thermally treated ECP-305. None of the undamaged samples has failed during that time.

Screening tests for removal of metallized reflectors from substrate materials (to allow subsequent replacement) have continued at NREL.

Six solvents have been tested using coupons (0.5 inch by 1 inch) of ECP-305 on aluminum substrates. Both thermally treated and non-thermally treated mirror samples have been used. All six solvents were effective in dissolving the PMMA film but were unable to dissolve the silver/adhesive layers. Chloroform, acetone, and ethyl acetate were the best candidates in terms of speed in removing

the polymer film. Acetonitrile, toluene, and methylene chloride (in that order) were slower in dissolving the film.

To remove the silver/adhesive layers, several paint strippers have also been tested. Four commercially available products have been screened. Of these, one (Klean Strip KS-3 paint stripper) appears promising. This product dissolved all of the adhesive within 30 minutes; the residual adhesive could be removed with running water without mechanical scraping. Further tests are continuing.

Progress was made with regard to several subcontract activities related to alternate reflector material. Responses to a solicitation for letter of interest for research and development in alternate reflector material were received from interested industrial concerns. Reviews of technical and cost analysis of these proposals were initiated. In a separate activity, a consultant agreement was initiated with Business Factors, Inc. to carry out a cost analysis of metallization of polymer films. The purpose of this task is to determine whether other metallized polymer mirror configurations, which have some potential for meeting the optical and durability goals, can be fabricated for significantly less cost than ECP-305, the present state-of-the-art poly reflector.

Several silvered fluoropolymer film reflectors prepared during the last quarter at NREL are under test. Initial optical characterization was performed, and samples have been introduced into accelerated weathering exposure. Visually, these materials exhibit poor specularity.

Milestones

A milestone report titled "Alternative Reflector Materials for Solar Thermal Electric Application; Material Screening Results and Establishment of R&D Plan During FY1991" was completed and delivered to DOE in fulfillment of Milestone IIA3, "Document investigation of alternate reflector materials." Major progress during FY1991 as documented in the report included the following.

- Sample materials have been provided by interested companies for evaluation of performance and durability.

- A number of candidate alternate reflector materials were prepared at NREL and are presently being subjected to exposure testing.

- Progress was made toward placing a number of collaborative subcontracted research activities with industrial partners.

A milestone report titled "Replaceable Reflector Materials R&D at NREL during FY 1991" was completed and delivered to DOE in fulfillment of Milestone IIA3 entitled "Document field replaceable reflector material results." Major progress during FY 1991 as documented in the report included the following.

- A planning meeting was held at NREL to establish a plan for the development of a market-usable, replaceable reflector material.

- Based upon recommendations from this meeting, several screening experiments have been carried out at NREL to evaluate the ease of removability and replacement of existing products.

- Several subcontracted activities were proposed but have not yet been initiated.

Planned activities for next quarter

- Recommendations for funding will be made for subcontracted alternate reflector research and development, and contract negotiations will begin.

- Parallel and complementary work at NREL on alternate reflector materials will continue; candidate constructions will be prepared, will be optically characterized, and will be subjected to accelerated and real-time durability testing.

- Plans for expanded outdoor material exposure testing will begin.

B. Power Conversion

1. Central Receiver Technology

Objective: Develop central receiver technology in direct support of the central receiver commercial applications programs.

Accomplishments:

Molten Salt Pump and Valve Test final report in approval process.

The report on the molten salt pump and valve test was peer reviewed last quarter. Minor modifications are being made on the report and then it will be sent through for management approval and publication.

Panel research experiment final report in preparation.

The main body of the report on the panel research experiment has been completed. However, the appendices need to be completed before the report can be sent out for peer review and publication.

Volumetric air receiver absorber material testing.

This past quarter New Mexico State University (NMSU) prepared an ASME paper documenting the results of its tests on the volumetric air receiver materials at its solar furnace. Based on the test results, the porous ceramic foam will not achieve the high thermal efficiencies required for a volumetric receiver. The material is robust and can handle high temperatures; however, at the temperatures required for electricity production (1050^{o}F) the porous ceramic foam is not the optimal material. The report is NMSU's documentation to Sandia on the results of the testing. The report is currently being reviewed at Sandia. NMSU has not done any other testing on other materials.

Second generation central receiver study.

A meeting was held in Albuquerque in August to discuss finalizing the Second Generation Central Receiver Study. The Second Generation Central Receiver Study is comparing the cost and performance of molten salt and volumetric-air central receiver power plants. The study is a joint US/Germany effort and was initiated in the fall of 1989. The study is intended to provide guidance in directing future US and German government programs to develop solar-thermal-electric technology. The study is focusing on 30 MWe and 100 MWe plants with capacity factors in the 40 to 50% range. All the sections to the report have been written and it is being prepared for peer review by the IEA.

Planned activities next quarter

- The final report on the pump and valve loop experiment will be published next quarter.
- The summary report of the design, construction, and testing of the panel research experiment will be completed next quarter.
- Prepare a plan for supporting industry and the utilities in the specification and design of the validation plant.
- Prepare a plan for a test program to validate molten salt component design in support of the validation plant.
- Prepare a proposal, with CIEMAT (Spanish) for testing the internal film receiver at the Plataforma Solar de Almeria. This is contingent on CIEMAT's agreement to participate.
- Initiate a contract with Bechtel for design and fabrication of a volumetric receiver absorber to be tested at the Plataforma Solar. This activity is contingent on the approval of the IEA/SSPS to test the absorber.
- Initiate testing of volumetric receiver absorber materials at New Mexico State University. Wire mesh materials will be tested to support the Bechtel absorber design.

Initial control algorithm developed for Solar Two Receiver.

An initial control algorithm was developed for the Solar Two central receiver power plant. The algorithm simultaneously regulates the receiver outlet temperature and prevents thermal-fatigue damage of the receiver tubes. The algorithm is similar to one developed for the cavity receiver that was tested at the Central Receiver Test Facility in 1988. Due to the differences in the way solar flux is introduced on to the receivers during cloud-induced transients, the Solar Two receiver will be somewhat more difficult to control than the cavity receiver. However, simulations have indicated that automatic control during severe cloud

transients is feasible. A paper was written which summarizes this work and submitted to the 1991 ASME Conference, Solar Energy Division.

Molten Salt Pump and Valve Test final report in approval process.

The report on the molten salt pump and valve test was peer reviewed last quarter. Minor modifications are being made on the report and then it will be sent through for management approval and publication.

Planned activities next quarter

- The final report of the pump and valve loop experiment will be published next quarter.
- The summary report of the design, construction, and testing of the panel research experiment will be completed next quarter.
- Prepare a plan for supporting industry and the utilities in the specification and design of the validation plant.

2. Dish Receiver Technology

Objective: Develop liquid metal reflux receiver technology in direct support of industry-led commercial programs and investigate advanced concept for long-term reliable and low-cost receivers.

Accomplishments

Pool boiler methods and materials bench testing started.

Bench testing has begun on the first in a series of four pool-boiler bench test receivers. The series of tests will determine the boiling enhancement method to be used on the next-generation receiver. The tests are using NaK-78 working fluid and Haynes-230 envelope material, as planned on the full-size receiver. The first test module contains a single laser-drilled cavity in the heated surface, simulating the EDM cavities in the first-generation receiver. The laser-drilled pits are far cheaper to implement, and have similar dimensions to the EDM cavities.

Initial testing showed intermittently stable boiling at several operating temperatures. The addition of a very small amount of xenon provided boiling stability at most operating temperatures. The devices were baked out at 600°C for a full day, and contained an oxygen getter strip (zirconium), and so were very clean prior to testing. The literature indicates an effect of cleanliness (oxygen content) on boiling behavior.

Additional testing will include two types of sintered powder boiling enhancement surfaces, originally demonstrated by Thermacore, and a bare-wall control vessel. In addition, various buffer gases, including helium and perhaps trace amounts of oxygen, may be tried. The most successful technique will be used for the next-generation on-sun receiver, and the vessel will be used for the long-term bench test.

Steam-cleaning of NaK-contaminated parts demonstrated.

Hardware for using superheated steam to react residual NaK in parts has been demonstrated. The system provides steam at a controlled rate in nitrogen to the part, causing a reaction that removes the NaK from the part. The reaction products include a small amount of sodium- and potassium-hydroxide, water, and hydrogen. Prior methods have resulted in waste streams of large amounts of alcohol contaminated with the reaction products. The new method reduces employee exposure to hazardous materials and operations, and results in a safer waste stream.

A piece of tubing and a sodium fill vessel were cleaned successfully, removing several grams of sodium. The operations took about 15 minutes, compared to hours or days for alcohol reaction. Part temperatures and hydrogen evolution were monitored for safety and to determine reaction completion. The total reaction products were less than a cup of water and caustic. Now that the operation has been characterized, a second-generation steam-cleaning system will be developed to provide ease-of-use on a routine basis while providing for safety and waste-stream security.

Cummins durability heat-pipe posttest analysis and next-generation design completed.

Last quarter, Cummins demonstrated over 360 hours on-sun with the Thermacore heat-pipe receiver. Several hot spots developed, though none were as serious as previous receivers. Upon disassembly, wick delamination from the absorber surface was apparent. Insufficient wall-wick bonding was at fault, with a clean break between the wall and the wick.

Thermacore developed and implemented a thermal cycling rig to simulate the startup cycles on the receiver, hoping to reproduce the failure mode. Thermal cycling did not cause delamination in any test. Further investigation through sectioning indicated that the plating thickness on the absorber was not sufficient to meet specifications. The electroless nickel plating flows at sintering temperatures, providing a braze joint between the wick and the wall. Plating thicknesses less than 1 mil flowed on the wall but not into the wick, while thicker plating flowed into the first layer of the wick. Pull tests and thermal shock tests were used to verify that the thicker plating prevented separation at the wall-wick bond. Thermacore has worked with the plating shop and plating solution vendor to implement a quality control program that will assure sufficient plating on the next receiver. The next receiver's parts have been fabricated. The wick assembly will be applied, fabrication completed, and bench testing initiated in the first quarter of FY92.

STM bench-test device tested at Sandia and STM.

STM assembled and tested a bench-scale receiver incorporating the new artery design and their sintered screen wick. The bench test was designed to verify wick and artery performance and to explore artery priming techniques. The device was operated with a gas-fired heater at STM, and showed some tendency to dry out. However, the peak heat flux was uncertain. Tests at Sandia with a lamp assembly showed dryout occurred at about 26 W/cm^2, which is far below expectations. This flux is high enough that the artery must be primed. Dryout occurred across the whole surface, indicating the limit is not in the wick, but in the sodium supply to the wick. Currently tests are planned to determine if the artery pedestal has enough flow cross-section to provide sufficient sodium to the wick. In addition, RGA analysis of the device after testing indicated significant

quantities of nitrogen and argon, indicating a leak in the heat pipe. A leak has not been located yet.

Completed metallurgical analysis of first on-sun pool boiler.

A destructive postmortem analysis of the first on-sun pool-boiler receiver has been completed. The area surrounding the leak was examined by scanning electron microscopy and by cross-sectioning. Small areas of localized melting were found, but there was no remaining evidence of cracking due to creep or fatigue damage. The entire interior and exterior absorber surfaces were examined for evidence of local melting or cracking (none found) as well as for corrosion and dissolution. The liquid-sodium side was unaffected, but the air side was oxidized to a depth of 0.001 inch. The artificial cavities were damaged by metal loss near the surface, resulting in chamfered hole openings. The damaged areas appear to be fatigue fracture surfaces, initiated either during manufacture or during operation. Metallographic examinations of the receiver rim weld found no evidence of cracking. It was concluded that the physical evidence alone could not determine the cause of the leak. A fatigue analysis based on stress analyses and the thermal history of the receiver suggests that fatigue did not cause the leak. Heat-transfer analyses indicate that the most likely cause of the leak was transition to film boiling or flooding during an unusually-cold restart. This work has been documented in detail in recent reports (see Publications). The findings are being incorporated into the design of the next-generation receiver.

Sandia solar-blind imaging radiometer under development.

A dedicated infrared thermal imager is being developed to support reflux receiver testing. The new Sandia infrared camera operates in an atmospheric "water band" near 1.9 μm. The transmission through the whole atmosphere in this band is essentially zero, resulting in virtually no solar contamination of the image. At a distance of 5 meters, the transmission ranges from 70% to 90%, depending on the humidity. Thermocouples mounted on the receiver provide absolute temperature calibration.

The system consists of an uncooled lead sulphide (PbS) vidicon, a specially designed lens, a specially designed narrow-band transmission filter, and a remotely positioned filter wheel. The entire system is mounted in a weather-

proof housing. The system is substantially less expensive than the commercially available Inframetrics system, has much better spatial resolution, and does not require liquid nitrogen cooling.

Detailed design of the camera system has been completed, and all parts have been received.

On-sun receiver documentation in review.

A second draft version of the on-sun documentation has been reviewed by the authors, and most of the figures have been incorporated. The document has been given to Tech Reps, who will provide final formatting and printing services, as well as provide another level of review.

The documentation of the on-sun x-ray studies has also been completed and has begun review. Both papers will be published this quarter.

TBC-1 readied for receiver testing.

The tracking problem identified during pool-boiler testing on TBC-1 has been resolved, and the dish has been tested on-sun over a period of a month. The complete cooling system has been upgraded to meet ES&H standards. About 1/4 of the mirrors have been replaced with clean facets to improve performance of the dish. A new alignment position has been established, and alignment will be performed early in the next quarter. The dish will be used in the furnace mode to test the Dynatherm receiver.

Hybrid receiver solicitation proposals received.

The objective of this solicitation is to design, fabricate, ground-test and field-test a reflux receiver capable of operation with concentrated solar flux or natural gas. Researchers anticipate that development of the receiver is critical to successful commercialization of the dish/Stirling concept by providing penetration to those markets where continuous or reliable power generation is required.

During this quarter, proposals were received from three qualified industrial concerns. Based on the quality and different approaches that emerged in the proposals, researchers are considering making two awards. The award date may

be delayed from the original plan because of additional work required in the contracting process in making multiple awards.

Planned activities for next quarter

- Testing will be completed on the bench test pool boilers. The test cell will be available early in the quarter when testing of the STM bench test is completed. The results of the bench testing will be applied to the next on-sun design.

- Complete fabrication of next-generation Cummins/Thermacore receiver. Thermacore will implement their new plating quality control program and complete the fabrication of the receiver. Ground testing on lamps will begin. On-sun testing of the receiver awaits the completion of a new test site at the Cummins Abilene facility. Fabrication funding is provided by NREL, while on-sun testing will be supported by the joint-venture program.

- The solar-blind imaging radiometer will be assembled and tested.

- The Dynatherm heat-pipe receiver will be mounted on TBC-1 for testing following alignment and cold-water calorimetry of the dish and furnace. The initial tests will be performed in the furnace mode in order to determine peak power limits. Testing will await completion and shakedown of the furnace hardware, expected late this quarter. The new thermal imaging system will also be applied to these tests.

- The analysis of the leak and the wick dryout of the STM bench test will be completed, and recommendations will be given to STM. The bench test will also be examined to verify that the artery was still primed.

- Publish x-ray and on-sun receiver reports.

  Based on the results of the first steam cleaning demonstration, hardware will be developed for ease-of-use and safety, and implementation will begin.

3. Dish Converter Solarization

Objective: In cooperation with industry, test and evaluate conversion devices applicable to solar thermal electric technology and respond to solar-specific issues. In particular, Stirling cycle heat engines are to be considered. These include a Stirling Thermal Motors kinematic Stirling engine and free-piston Stirling engines under final design by Stirling Technology Company and under preliminary design by Cummins Engine Company.

Accomplishments:

Stirling Thermal Motors (STM) continues to accumulate STM4-120 operating hours.

STM has now moved their offices and lab to a larger facility, the former Stirling Power Systems headquarters.

STM initiated operation of another STM4-120 engine in their new facility. Heat input is provided from direct-flame units--combustion gases pass directly over the heater heat tube bundle rather than transferring energy into a sodium heat-pipe. Although the temperature distribution is much more uniform with a heat-pipe, the direct flame units have been reliable to this point. As a reminder, STM accumulated more than 500 hours at the 8 to 12 kW level in the last quarter.

For this quarter, STM has reinstalled the engine and debugged all systems. The engine has been run another 100 hours, primarily in the 10-12 kW range. At the request of Detroit Diesel, the engine was also run up to 22 kW at lower pressure but 3600 rpm (normally, the engine is run at 1800 rpm). The purpose of the test was to determine the maximum heat input available using the direct-flame heater heads.

Fabrication of SNL gas-fired sodium evaporator nearly complete.

As described in the FY91-3 report, the first full-scale evaporator testing was conducted from December, 1990 to February, 1991. Unstable operation was observed in this first unit. The unstable operation was attributed to high vapor velocities in the critical 450-600 C range preventing liquid sodium from returning

to the lower manifold. Since the sodium was trapped in the upper manifold and the device contained no wick structure to allow the liquid sodium to wick downward, the tubes dried out and eventually overheated.

Also, as described in the previous report, a wick "sampler" was fabricated and tested. This heat-pipe consisted of four different wick designs in a single unit. The results indicated that extending the wicks into the upper manifold combined with a few tubes with liquid return lines would solve the problems encountered in the first full-scale evaporator. As a precautionary measure, we decided to increase the depth of the lower manifold, allowing a larger sodium inventory. A larger volume of sodium should ensure that no dryouts occur, especially in the high vapor velocity range. Finally, the liquid return system was changed slightly. In the first full-scale unit, the condenser consisted of a 1-m x 50.8-mm (2") OD tube. Condensed sodium refluxed on the inner tube surface and was channeled into 9.5-mm (3/8") tube which opened above the upper manifold. The second evaporator will include a 25.4-mm (1") OD tube concentric with the 50.8-mm (2") condenser tube. With this design modification, vaporized sodium flows upward inside the 25.4-mm (1") tube and is deflected outward and then downward along the condenser tube. This change will allow the vapor to assist the liquid sodium return system, further reducing the possibility of entrainment.

A photo of the pieceparts comprising the second full-scale unit is shown in Figure 2. Figure 3 is a closeup of the evaporator section, illustrating the wicks extending into the upper manifold.

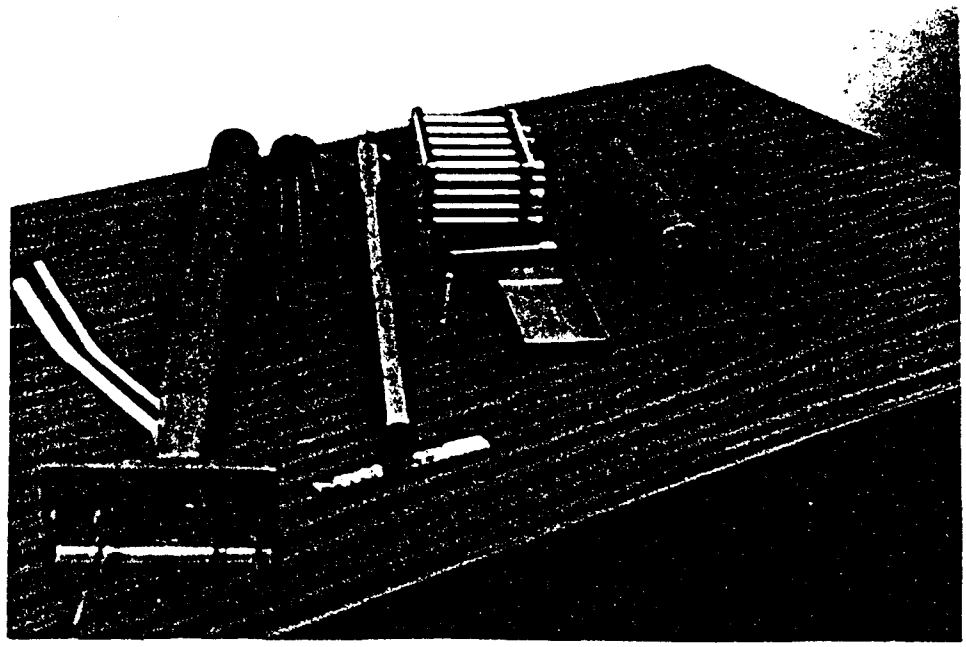

Figure 2 - Pieceparts for SNL's Second Full-Scale, Gas Fired Evaporator/Condenser.

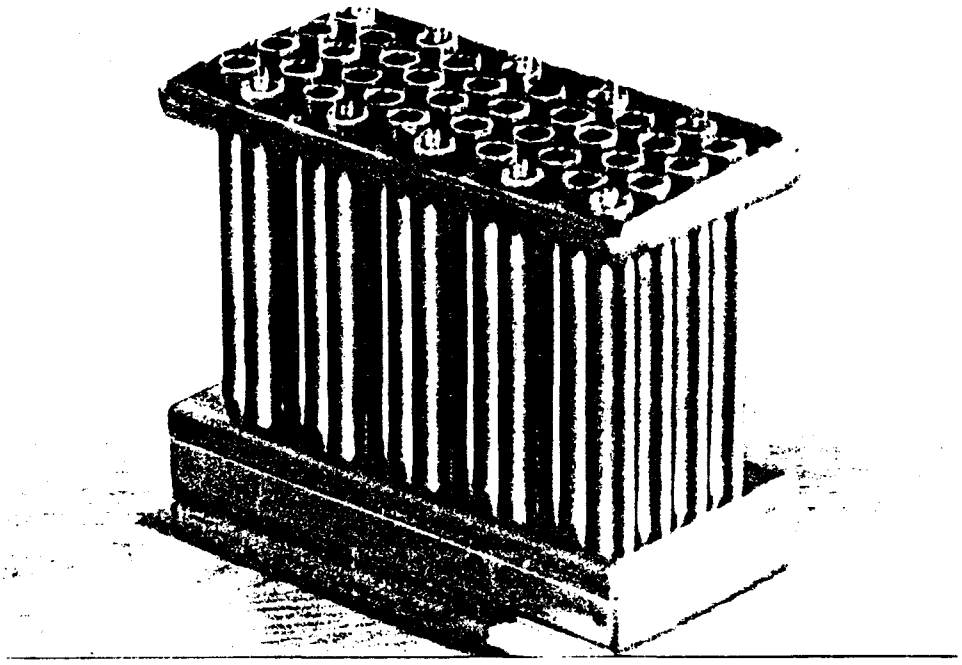

Figure 3- SNL's Second Gas-Fired Sodium Evaporator-Upper Manifold Plate Removal.

Fabrication was delayed when the primary welder in the SNL shops was out for medical reasons. All fabrication is now complete with the exception of the final welds on the upper and lower manifolds. Photos were taken of the evaporator before these welds were to be performed. Following the manifold welds, surface thermocouples will be brazed onto several evaporator tubes. Bakeout and fill operations will take approximately one week. Testing on the new unit will begin in mid-October.

Planned activities next quarter

- Conduct 200 hour-test on SNL gas-fired sodium evaporator.
- Award cost-shared kinematic Stirling-based power conversion system contract to Detroit Diesel Corporation.
- Evaluate Stirling Technology Company linear alternator ASCS concept.

III REIMBURSABLE PROGRAMS

National Solar Thermal Test Facility

Accomplishments

A third series of military aircraft material hardness test for Northrop/U.S. Air Force were conducted.

Aircraft materials were installed in the windowed wind tunnel behind the high-speed shutter in the center test bay of the NSTTF solar power tower. Test samples were exposed to simulated nuclear thermal pulses. The test plan required that the peak flux be held within +/- 3.5% of the specified level. The highest solar insolation in July and August was typically 930 W/m^2. Usually the peak insolation would be around 980 W/m^2 during this time. Because of the relatively low insolation and the tight tolerance required for the peak flux, Sandia and Northrop agreed to postpone part of the testing until Northrop returns in October.

The NSTTF tested material samples for the David Taylor Research Center.

Sixty-four material samples were exposed to simulated nuclear thermal pulses using the high-speed shutter and the heliostat control system at the NSTTF. The tests were conducted for the U.S. Navy David Taylor Research Center.

Planned activities for next quarter

- A fourth series of military aircraft material hardness test for Northrop/U.S. Air Force is scheduled to start in October. This test series will complete testing of materials from the July/August test series as well as new test samples.

- BDM is scheduled to conduct a radome test for the U.S. Air Force at the NSTTF in November. A fiber glass radome will be exposed to several fluence levels simulating nuclear thermal pulses. Radar will be transmitted through the radome before, during, and after the test.

Publications completed in FY91

Adkins, D. R., Godett, T.M., "An Update on the Development of Heat-Pipe Solar Receivers for Stirling/Dish-Electric Systems," Second ASME-JSES-JSME International Solar Energy Conference, Reno, Nevada, March 1991. (Proceedings pp 187-193)

Alpert, D.J., et al., "The Development of Stretched-Membrane Heliostats in the United States," Solar Energy Materials 21, (1990) pp 131-150.

Bator, P. A. and Dowling, R. L., "Construction of the Molten Salt Pump and Valve Loops," SAND90-7031; May 1991.

Chavez, J.M., Rush, E.E., Matthews, C.W., "Design, Construction, and Testing of the Direct Absorption Receiver Panel Research Experiment," SAND91-7631, Albuquerque, New Mexico: Sandia National Laboratories, May 1991.

Grossman, J. W., Houser, R. M., Erdman, W. W., "Prototype Dish Testing and Analyses at Sandia National Laboratories," SAND91-1263C for presentation at the 1991 NSME, JSES, KSES, Maui, Hawaii, April 1992.

Menicucci, D. F., "Recent Developments of the Solar Thermal Design Assistance Center," Semi-annual Newsletter of Sandia National Labs STDAC, February 1991.

Menicucci, D. F., Kolb, G. J., Albert, D. J., Chavez, J. M., "Consider a Solar Electric Power Plant," Sandia special publication, SAND91-0235, March 1991.

Menicucci, D. F, "Solar Thermal Design Assistance Center," Sandia special publication, SAND91-0234, March 1991.

SOLTECH Proceedings: Solar Industrial Program, Volume I and Volume II, Solar Thermal Electric Program. (April 1991). SERI/CP-250-4254. 656 pp. Available NTIS: Order No. DE91002163. ACCNR: 12307

"Facet Development for a Faceted Stretched-Membrane Dish by SAIC,"SAND Contractor Rpt. 91-7008, Science Applications International Corporation, San Diego, California, 1991.

"Facet Development for a Faceted Stretched-Membrane Dish by SKI, "SAND Contractor Rpt. 91-7009, Solar Kinetics Inc., Dallas, Texas, 1991.

"Design of Solar Concentrator Support Structure, Pedestal and Controls," SAND Contractor Rpt. 91-9007, WGAssociates, Dallas, Texas, 1991.

Publications in Progress:

Andraka, C. E., et.al., "Sodium Reflux Pool-Boiler On-Sun Test Results," SAND89-2773.

Brown, D., "Design and Cost of the First Commercial Stretched-Membrane Heliostat," Sandia National Laboratories, SAND90-7038, July 1991.

Grossman, J. W., "Static Load Testing of a Heliostat Drive," SAND 90-2624, to be published.

Grossman, J. W., Houser, R. M., Erdman, "Prototype Dish Testing and Analysis at Sandia National Laboratories," SAND 91-1263C, for presentation at the 1992 NSME, JSES, KSES, Maui, Hawaii, April 1992.

Grossman, J. W., Houser, R. M., Erdman, W. W., "Testing of the Prototype Facets for the Stretched-Membrane Faceted Dish, SAND 91-2202, to be published.

Grossman, J. W., Houser, R. M., Erdman, W. W., "Testing of the Single-Element-Stretched Membrane Faceted Dish," SAND 91-2203, to be published.

Jorgensen, W. W., Wendelin, G. T., Carasso, M., "Determination of Accuracy of Measurements by SERI's Scanning Hartmann Optical Test Instrument," SERI/TP-257-4190. ACCNR: 12187. Golden, Colorado: Solar Energy Research Institute.

Jorgensen, G., "Comparison of Predicted Optical Performance with Measured Results for Dish Concentrators." SERI/TP-255-4045. ACCNR:12031. Golden, Colorado: Solar Energy Research Institute

Konnerth, A., "Design and Cost of the First Commercial Stretched-Membrane Heliostats," Sandia National Laboratories, SAND90-7038.

Mancini, T. R., "Analysis and Design of Two Stretched-Membrane Parabolic Dish Concentrators," accepted for publication in the August, 1991 issue of the ASME Journal of Solar Energy Engineering.

Mancini, T. R., and Boldt, K. R., "The LaJet Innovative Concentrator: Design and Performance." Sandia Technical Report.

Moreno, J. B., et. al., "Reflux Pool-Boiler as a Heat-Transfer Device for Stirling Engines: Postmortem Analysis and Next-Generation Design," SAND92-1103C for 26th IECEC, Boston, Massachusetts, August, 1991.

Moreno, J. B., et. al.,"X-Ray Observations of Boiling Sodium in a Solar Reflux Pool-Boiler Receiver," SAND91-1538.

Schissel, P., Jorgensen, G., Pitts, R., "Application Experience and Field Performance of Silver Polymer Reflector Surfaces." SERI/TP-255-4046. Golden, Colorado: Solar Energy Research Institute.

Schissel, P., Kennedy, C., Shinton, Y., King, D., "Tunneling and Delamination in Silvered Polymer Mirrors." SERI/TP-253-3960. ACCNR: 11922.

Smith, D.C., Chavez, J.M., Rush, E.E., Matthews, C.W., "Report on the Test of the Molten Salt Pump and Valve Loops," SAND91-1747, Albuquerque, New Mexico: Sandia National Laboratories.

Wendelin, T. J.; Jorgensen, G. J.; Wood, R. L., "SHOT: A Method for Characterizing the Surface Figure and Optical Performance of Point Focus Solar Concentrators." SERI/TP-253-3938. ACCNR: 11898. Golden, Colorado: Solar Energy Research Institute.

Presentations

Adkins, D. R., Godett, T.M., "An Update on the Development of Heat-Pipe Solar Receivers for Stirling/Dish-Electric Systems," Second ASME-JSES-JSME International Solar Energy Conference, Reno, Nevada, March 1991. (Proceedings pp 187-193)

Alpert, D. J., Kolb, G. J., Chavez, J. M. "Today's Central Receiver Power Plant," SAND91-1890C, Invited Plenary Paper, ISES 1991 World Congress, August 14-17, Denver, Colorado

Beninga, K., et al., "Design and Fabrication of a Market-Ready Stretched-Membrane Heliostat," presented at 1991 ASME-JSME-JSES International Solar Energy Conference, Reno, Nevada, March 17-22, 1991.

Chavez, J. M., Rush, E. E., Matthews, C. W., Stomp, J. M., Imboden, J. and Dunkin, "Design, Construction and Testing of the Direct Absorption Receiver Panel Research Experiment," Second ASME-JSES-JSME International Solar Energy Conference, Reno, Nevada, March 1991.

Diver, R.B., "Solar Thermal Electric Program Power Conversion Technology Development," SOLTECH '91, San Francisco, California, March 1991.

Grossman, J. W., Houser, R. M., Erdman, W. W., "Prototype Dish Testing and Analysis at Sandia National Laboratories," SAND 91-1263C, to be presented at the 1991 ASME, JSES, KSES, Maui, Hawaii, April 1992.

Hoffman, E. L., and Stone, C. M., "Coupled Thermal-Structural Analyses of a Reflux Pool-Boiler Solar Receiver," SAND 91-1321C, Sandia National Laboratories, Albuquerque, to be presented at the ASME-JSES-JSEM International Solar Energy Conference, Maui, Hawaii, April 4-8, 1992.

Hogan, R. E., "Numerical Modeling of Dish/Stirling Reflux Solar Receivers," Second ASME-JSES-JSME International Solar Energy Conference, Reno, Nevada, March 1991. (Proceedings pp 215-222)

Jorgenson, G., "Comparison of Predicted Optical Performance with Measured Results for Dish Concentrators," ISES 1991 Solar World Congress, Denver, Colorado, August 1991.

Klimas, P. C., "Solar Thermal Electric Program Cooperative Projects," SOLTECH '91, San Francisco, California, March 1991.

Klimas, P. C., "The Department of Energy Solar Thermal Electric Program," Plenary address presented at Second ASME-JSE-JSME International Solar Energy Conference, Reno, Nevada, March 1991.

Klimas, P. C., "Modular Solar Thermal Electric Systems," 1991 International Summer Meeting, American Society of Agricultural Engineers, Albuquerque, New Mexico, June, 1991.

Kolb, G. J., " Reliability Analysis of a Salt-in-Tube Central Receiver Power Plant," Second ASME-JSES-JSME International Solar Energy Conference, Reno, Nevada, March 1991. (Proceedings pp 259 - 266)

Mancini, T. R., "Analysis and Design of Two Stretched-Membrane Parabolic Dish Concentrators," presented at the 1991 ASME-JSES-JSME International Solar Energy Conference, Reno, Nevada, March 18, 1991.

Mancini, T. R. , "The DOE Solar Concentrator Project," presented at SOLTEC 91, San Francisco, California, March 28, 1991.

Menicucci, D. F., "Solar Energy - A Viable Technology for Today and Tomorrow," presentation to the Albuquerque Science Teachers Association, March 1991.

Menicucci, D. F., "A Review of the Solar Thermal Design Assistance Center," presentation at SOLTECH 91, San Francisco, California, March 1991.

Application Experience and Field Performance of Silvered Polymer Reflectors," ISES 1991 Solar World Congress, Denver, Colorado, August 1991.

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