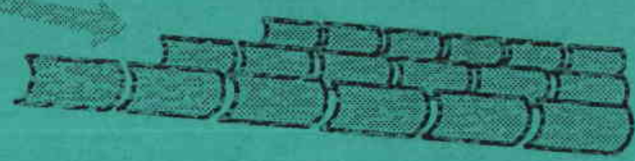

The DOE

Solar Thermal Electric Program Annual Operating Plan

Fiscal Year 1991

Submitted by:

Sandia National Laboratories
Albuquerque, New Mexico

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Sandia
National
Laboratories

SERI

SOLAR THERMAL ELECTRIC PROGRAM

FY91 Annual Operating Plan

October, 1990

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PREFACE

This Annual Operating Plan (AOP) provides detailed plans for the fiscal year 1991 (FY91) activities of the Department of Energy's (DOE) Solar Thermal Electric Program (STEP).

This year's plan differs from those of earlier years in that it emphasizes accelerated commercialization of solar thermal electric technologies and heavily involves the private sector in its various elements. This AOP integrates the work of the two field laboratories responsible for executing the plan: Sandia National Laboratories and the Solar Energy Research Institute.

SECTION I

SOLAR THERMAL ELECTRIC PROGRAM OVERVIEW

PROGRAM GOAL:

The goals of the Solar Thermal Electric program are to

- Increase our environmentally neutral, renewable energy supply options.
- Reduce our dependence on imported energy sources.
- Open new domestic and overseas markets.
- Enhance our national superiority in energy technology.

PROGRAM STRATEGIES:

- Through cooperative ventures, increase industrial participation in both the planning and execution of program elements.
- Increase proactive design assistance activities intended to enlarge the technology's user, supplier and decision-making constituency.
- Utilize the analytical and experimental capabilities of the program to support the technology development needs of the constituency.
- Strengthen the scientific base of the program, particularly in the industrial sector.

PROGRAM STRUCTURE:

The Solar Thermal program is structured to provide a balance of activities that exploit near-term commercialization opportunities, to improve readiness to meet long-range performance and cost goals, and to maintain a forward looking research thrust to open new applications.[1]

There are two major program elements:

I. Commercial Applications
II. Technology Development

Each activity has a number of tasks as shown in Figure I-1, Work Breakdown Schedule.

ACTIVITY SUMMARY:

The objective and key milestones are listed below for each activity.

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[1]"Bringing Solar Thermal Technology to the Marketplace," U.S. DOE Report to Congress, CE-0233, Aug. 1988.

I. COMMERCIAL APPLICATIONS

Objective: At the initiative of industrial partners, collaborate with, and/or cost-share in, the development of fully integrated systems that will result in 1) competitive solar thermal electric systems based on refinement and optimization of current commercially available systems, and 2) advanced solar thermal electric systems that will improve performance and cost competitiveness in the mid-1990's and beyond.

Key Milestones:

- Identify R&D based improvements to commercial solar thermal electric systems through in-field testing (FY 91).
- Initiate operation of the Dish/Stirling Joint Venture electric systems experiment (FY 93).
- Initiate operation of a utility-scale molten salt central receiver power plant (FY 95).

II. TECHNOLOGY DEVELOPMENT

A. CONCENTRATOR TECHNOLOGY

Objective: Develop cost effective concentrators and optical materials to support industrial commercialization efforts.

Key Milestones:

- Stretched-membrane heliostat commercial readiness established (FY 91).
- Stretched-membrane dish commercial readiness established (FY 95).
- Commercially available, low cost, high performance polymer reflective material with 10-year durability (FY 95).

B. POWER CONVERSION TECHNOLOGY

Objective: Develop components and subsystems needed to establish commercial readiness of solar thermal electric technology to penetrate major national and international markets by the late 1990's.

Key Milestones:

- Performance and readiness of reliable 25 kW Stirling engine confirmed by non-solar tests (FY 91).
- Performance and readiness of isothermal, liquid metal vapor receivers for parabolic dish concentrators verified by solar tests (FY 91).
- Complete integration of dish, receiver, engine, and controls into a second generation prototype system (FY 92).

Figure I-1. SOLAR THERMAL ELECTRIC PROGRAM WORK BREAKDOWN SCHEDULE

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

1. CENTRAL RECEIVER TECHNOLOGY
2. DISH RECEIVER TECHNOLOGY
3. DISH CONVERTER SOLARIZATION

SECTION II

FY 1991 TASK DETAIL

I. COMMERCIAL APPLICATIONS

The three major categories of solar thermal electric technology, central receiver systems, dish/engine systems and parabolic trough collector systems, have all evolved to levels where some next development steps are most appropriately conducted with industrial participation in cost-shared commercial applications. These government/industry partnerships will produce teams which are uniquely qualified to rapidly advance each technology. The partnerships will combine the manufacturing, marketing and management skills of industry with the solar-specific experience base and analytical and experimental capabilities of the government laboratories. The validity of this reasoning has already been demonstrated by the success of the Cummins Engine Company/government laboratory teaming on the Cummins 5-kW_e dish/Stirling commercialization effort. Cummins management has repeatedly stated that their progress would not have been possible without the special expertise contributed by the DOE Solar Thermal Electric Program. The commercial applications portion of the program will expand and formalize this effort through additional joint industry/laboratory cooperative activities, tailored for each technology category, that would accelerate commercial usage of solar thermal electric systems with highly leveraged government resources. These partnerships will build on the continuing Technology Development portion of the program. The Technology Development and Commercial Applications will complement each other with each being stronger and more relevant through mutual interaction.

A. CENTRAL RECEIVER COOPERATIVE PROJECTS

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

Rationale: A large knowledge-base has been accumulated which suggests that it is possible to construct a central receiver power plant (using molten nitrate salt as the working fluid) that would reliably produce environmentally benign electrical energy which is independent of foreign fuel supplies. The cost of this power is expected to be comparable to the price charged by many U.S. utilities now using fossil fuels or nuclear energy. The last major hurdle to demonstration of this technology was overcome with the successful conclusion of testing of molten salt pumps and valves sized for a 60 MW_e power plant. In addition, a recently completed reliability study which integrated reliability data from Sandia experiments and other solar power plant projects such as Solar One, Themis, and the 280 MW_e of SEGS capacity indicated that the salt-based technology can achieve the availability goal required for economical power production. Conversion of the 10-MW_e Solar One plant and construction of a 30 MW_e power plant are two possible utility scale projects currently being discussed by industry.

FY90 Accomplishments: None, this is a new program.

FY91 Task Description: Develop a sound technical presentation regarding the status of current central receiver molten salt technology and present this *information* to interested organizations. Possible candidate organizations include southwestern utilities, state energy and public utility commissions, and environmental quality agencies. Conclude the presentation with descriptions of currently planned joint venture projects. Current industry-initiated preliminary plans include a retrofit of the 10 MW_e Solar One and a 30 MW_e project. Specific activities include:

- Prepare and make a technical presentation to a review committee whose members include public utilities and industrial concems familiar with solar electric technology.
- Make contact with candidate organizations and establish interest level regarding a visit by the laboratories.
- Update technical presentation reflecting input from the review committee and contacts with candidate organizations.
- Make presentations to the strongest interested organizations concluding with descriptions of currently planned central receiver joint venture projects.
- Enter into cost-shared agreements with industry to support site-specific evaluation or design activities for a utility scale demonstration.

Major Milestones:

Dec 1990	Make presentation to the review committee.
Feb 1991	Initiate presentations to organizations interested in central receiver commercialization.
Sep 1991	Present a report to DOE summarizing results of interactions with outside organizations.

		Budget
Resources:	In-House FTE:	292K
	Subcontracts:	350K
	Total:	642K

B. DISH/ENGINE COOPERATIVE PROJECTS

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

Rationale: In response to a formal request for information, U.S. industry has indicated that a remote solar electric generating system based on a parabolic dish concentrator and Stirling cycle converter can be economically competitive in a wide market in the mid-1990s. This program element will offer industry the opportunity to realize this market/technology goal on a faster time scale and at a lower technical and financial risk than would be otherwise possible.

FY90 Accomplishments: Responses to the request for information issued in late FY 1989 were evaluated and used to formulate a draft request for proposal which reflected industrial capabilities, market strategies and development time scales. Technical aspects of the request for proposal were finalized.

FY91 Task Description: Following release of the request for proposal, responses will be evaluated. Awards will be made dependent upon the appropriateness of the responses and the availability of funds. Development needs will be identified and addressed as part of the research and development portion of the program. Specifically,

- Release the request for proposal (RFP) for the dish/Stirling joint venture. This RFP is based upon input obtained from industry via a formal request for information.
- Evaluate each proposer's plan to develop and support commercial dish/Stirling electrical power generating systems.
- Award contract(s)
- Initiate laboratory activities addressing technology development needs identified by proposers.

Major Milestones:

Oct 1990	Issue request for proposal (RFP).
Jan 1991	Technical evaluation of RFP responses complete.
Apr 1991	Award contract(s),

		Budget
Resources:	In-House:	463K
	Subcontracts:	1500K
	Total:	1963K

C. PARABOLIC TROUGH COLLECTOR 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.

Rationale: The Solar Electric Generating System (SEGS) power plants located in Southern California generate 95% of the world's solar electricity, with an existing capacity of 354 MW at the end of 1990. These plants are operated and maintained by a U.S. subsidiary of LUZ International known as LUZ Engineering Corporation. LUZ has contracts to build another 300 MW by 1994, and projects an additional 1000 MW during the balance of the 1990s. The ability to implement these plans rests solely on the economic viability of the SEGS technology.

The costs associated with operating and maintaining (O&M) the SEGS plants have a significant influence on the economic viability of the technology. Currently, O&M costs account for approximately 15-20% of the plant electricity costs. Reductions in O&M costs, coupled with further reductions in capital costs and increases in conversion efficiency, would significantly enhance the marketability, further development, and widespread use of SEGS technology, as well as other solar power technologies currently being developed by the program.

FY90 Accomplishments: None, this is a new program in FY 1991.

FY91 Task Description: Identify the research and development (R&D) necessary to reduce O&M costs at SEGS plants. From this, formulate a multi-year plan for implementation of this R&D. The plan will focus on reducing costs on items that are common to SEGS technology as well as other solar technologies. After development of a draft plan, the adequacy of the plan will be tested by performing initial work on one of the identified important contributors to O&M cost.

Major Milestones:

Jan 1991	Begin identification of R&D necessary to reduce O&M costs.
Sep 1991	Finalize O&M cost reduction plan.

Resources:		Budget
	In-House FTE:	200K
	Subcontracts:	550K
	Total:	750K

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.

Rationale: In order to be effective, the solar thermal program requires a continual flow of information to and from the industry and users. The program's dissemination of R&D results to industry, and the reciprocal communication of industry's needs to the program, are necessary to keep the R&D relevant and to ensure developments are rapidly implemented by industry. This task fosters this flow of information by providing direct technical assistance to industry and users as well as through conferences, workshops, and publications. This task also provides an interface between CORECT, the solar thermal program, and industry to foster near-term applications of solar thermal systems in the international marketplace.

FY90 Accomplishments: During the past fiscal year, design assistance activities increased dramatically. The Solar Thermal Design Assistance Center (STDAC) received hundreds of requests for information, co-organized SOLTECH 90, provided technical assistance to major corporations such as Cummins Engine Company and Gould, Incorporated, assisted ten state and territorial governments, addressed five meetings of potential users, and published ten documents and brochures.

FY91 Task Description: The STDAC at Sandia receives requests for assistance and coordinates efforts with SERI to provide information and fulfill industry requests for technology evaluation, application screening, data, and design evaluation to assist industry and users in implementing the solar thermal option. Existing analysis tools and data will be used to provide this assistance, and additional industry needs for improved techniques will be considered and acted upon. The primary focus of the workshops and meetings activity is SOLTECH 91 where sessions will be conducted jointly with industry for specific federal, state and local agency and international audiences.

Major Milestones:

Mar 1991	Participate in the SOLTECH 91 joint meeting.
Ongoing	Provide assistance for specific solar thermal projects as requested.

Resources:		Budget
	In-House FTE:	270K
	Subcontracts:	183K
	Total:	453K

II. TECHNOLOGY DEVELOPMENT

A. CONCENTRATOR TECHNOLOGY

1. Heliostats

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

Rationale: The heliostat is the component of the central receiver system that collects and concentrates sunlight by tracking the sun. The heliostat comprises the largest cost element and has a direct effect on the overall performance of the central receiver system. Therefore, it is essential to minimize the cost without significantly sacrificing performance. The stretched membrane heliostat has gone through research and two stages of development and appears capable of best meeting program needs. Because of the simplicity and light weight of the stretched-membrane technology, these concentrators have the potential to cost significantly less than the current glass/metal concentrators.

FY90 Accomplishments: The optical evaluation of the two improved stretched-membrane mirror modules was completed and documented. Paralleling the FY89 effort of SAIC, a contract was placed with SKI for the design of a market-ready stretched-membrane heliostat, integrating the existing mirror module with a drive, support, and controls. SAIC began the fabrication of a prototype of its fully integrated, market-ready heliostat at the National Solar Thermal Test Facility (NSTTF) for testing and evaluation by Sandia.

Evaluation of the two large-area glass-mirror heliostats continued. Preliminary results for the ATS 150-m^2 heliostat showed very good optical performance; no evaluation has been performed on the 200-m^2 heliostat. The drive on the SPECO 200-m^2 heliostat was redesigned, and the heliostat reinstalled so testing could resume.

FY91 Task Description: SAIC will complete the fabrication and installation of its 100-m^2 market-ready heliostat. SKI will complete and document its design of a 50-m^2 market-ready heliostat, though there are not sufficient funds for SKI to fabricate a prototype.

Sandia will test the optical performance and durability of SAIC's 100-m^2 heliostat during a one-year evaluation program.

Evaluation of the optical performance of the two large-area glass-mirror heliostats will be completed and documented. Testing of the 150-m^2 heliostat will be performed using the low-cost drive, which will also be evaluated.

A demonstration of how to replace the reflective film on a membrane heliostat will be completed.

Major Milestones:

Nov 1990	SAIC completes fabrication of a prototype of its 100-m^2 market-ready heliostat.
Nov 1990	SKI completes a design for its market-ready heliostat.
Sep 1991	Completion of testing and documentation of two large-area glass-mirror heliostats and low-cost drive.

Resources:		Budget
	In-House FTE:	350K
	Subcontracts:	100K
	Total:	450K

2. Parabolic Dishes

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

Rationale: The parabolic dish is the largest cost element of a solar thermal dish system. It is also the first in the sequence of the system components -- dish, receiver, engine, whose performance determines the overall efficiency of the system. Therefore, if we are to develop cost-competitive dish-Stirling systems, it is essential that we optimize the performance of the dish; that is, develop dishes that minimize the cost of energy produced by the dish-Stirling system.

Stretched-membrane (SM) heliostats have demonstrated excellent optical performance and the potential for achieving low cost ($80/m^2). The success of this technology, as applied to heliostats, encouraged us to apply it to the development of light weight, high performance parabolic dish concentrators. The application of stretched-membrane technology to the forming of highly contoured, parabolic dishes is more complex than for making relatively flat heliostats. However, our estimates indicate that, through the use of stretched-membrane technology, we can reduce the cost of the parabolic dish ($200/m^2) by 40 to 50% while maintaining the high levels of optical performance currently available in glass-metal dishes.

FY90 Accomplishments: Activities in the Parabolic Dish Task area during FY90 included: the completion of SKI's 7-meter diameter SM optical element and the start of on-sun testing at the NSTTF; the initiation of the design of facets and support structure for the faceted SM dish; and the initial optical evaluation of facets for the faceted dish.

FY91 Task Description: We will conclude testing of the 7-m single element dish optical element and design of the stretched-membrane dish. From the single-element membrane and faceted membrane dish designs, we will select the most appropriate technology to support industrial dish/Stirling programs and begin first-generation prototype fabrication.

Major Milestones:

Dec 1990	Complete testing of the 7-meter diameter SM optical element.
Nov 1990	Phase I design review for the faceted dish project.
Jan 1991	Task 3 conceptual design review for the single-element SM dish project.

Resources:

	Budget
In-House FTE:	595K
Subcontracts:	1072K
Total:	1567K

3. Optical Materials

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

Rationale: Light-weight, durable, and efficient optical reflector materials are necessary to achieve cost and performance goals associated with various solar thermal concentrator technologies. The reflector material is a common element in all solar concentrators. High specular reflectivity with long service life and ease of replacement in the field are the key requirements.

FY90 Accomplishments: Delamination at the silver/polymer interface of silver polymer reflector materials destroys the specular reflectance of such mirrors, which is a primary obstacle to their further large scale use. Laboratory experiments at SERI have identified several methods that can slow the initiation and propagation of tunneling, the most common type of delamination. A thin layer of an inorganic material sputtered on the polymer film between the polymer and silver acts as an adhesive that resists the start and spread of tunnels. Other means of resisting tunneling have concentrated on edges formed when the mirrors are fabricated, because tunneling virtually always begins there. A heated knife and a laser have been used to cut mirrors, and microscopic examination of the resulting edges shows that fewer flaws are formed relative to more conventional cutting methods. Protecting edges after they are formed, by heat sealing for example, can also slow tunneling.

Improvement in optical durability of silver polymer reflector materials has been demonstrated through a joint SERI/3M project. Compared with earlier silver polymer constructions (ECP-300A), a more recent material (ECP-305) commercially produced by 3M continues to exhibit better corrosion resistance during accelerated weathering. In addition, significantly increased durability is exhibited by depositing a protective back coating on the latest generation silver polymer reflector materials. This SERI innovation demonstrates excellent performance in accelerated environments.

FY91 Task Description: Three principal areas of emphasis are planned. These include innovative approaches to delamination abatement and edge joining techniques, investigation of field replaceable reflector materials, and identification of candidate alternative reflector materials. Approaches to improve durability will continue at a reduced level. Specifically:

- Further investigate innovative approaches to tunneling.
- Continue examination of inorganic adhesion promoting layers between the silver and polymer films and introduce these into 3M's production films.
- Build on the Industrial Solar Technology field replaceable mirror material findings.
- With industry, identify alternate polymer films with enhanced durability and lower costs than the present generation of silver PMMA reflectors.

Major Milestones:

May 1991	Propose most promising solutions for delamination problem in film and begin process optimization.
Jul 1991	Document screening investigation of alternate reflector materials and establish R&D direction.
Sep 1991	Document field replaceable reflector material results.

		Budget
Resources:	In-House:	788K
	Subcontracts:	220K
	Total:	1008K

B. POWER CONVERSION

1. Central Receiver Technology

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

Rationale: Central receiver technology has reached a state of development where the fielding of a commercial-scale system is one next logical step to be taken. With the large resources required to realize this step, it is one which must be taken only after much careful consideration. It is likely that the next commercial-scale central receiver solar thermal power generator will be based on molten nitrate salt. The Program's unique analytical and experimental capabilities in these areas will be available to contribute toward specific technology development activities in support of commercial applications programs which may arise.

FY90 Accomplishments: Testing was concentrated on the direct absorption receiver (DAR), the molten salt pump and valve loops, and the volumetric receiver. Analysis emphasized central receiver systems using molten nitrate salt as the working fluid. Specific accomplishments include:

- Completed installation of the 6-m long panel research experiment (PRE), conducted molten salt flow characterization testing, and initiated low level solar testing.
- Reconfigured the salt loop at SERI to conduct high flux (simulated) film breakdown tests.
- Completed molten salt transport loop testing (6700 hours on hot loop, 2500 hours on cold loop).
- Completed a comparative evaluation of central receiver systems which use molten salt and air as the working fluids.
- Initiated optical characterization and solar furnace testing of volumetric receiver absorber samples (i.e., wire mesh and ceramic foams).

FY91 Task Description: Work will center on documenting experimental activities funded in earlier fiscal years and on maintaining readiness to respond to appropriate technology development needs generated through the central receiver commercial applications program. Specifically, we will

- Document the salt flow characterization and initial solar testing on the direct absorption receiver (DAR) panel research experiment (PRE).
- Conclude film breakdown experiments for DAR at SERI.
- Prepare a final report on the molten salt transport loop experimental activities.
- Coordinate the final report on the joint USA/FRG second generation central receiver status assessment.
- Maintain the Central Receiver Test Facility in a mothball status.
- Conclude volumetric receiver absorber material characterization activities at New Mexico State University.

Major Milestones:

Feb 1991	Complete final report on molten salt transport loop testing.
Mar 1991	Complete volumetric receiver absorber material characterization testing.
Apr 1991	Conclude coordination of the final report on USA/FRG second generation study.
May 1991	Issue status report on PRE salt flow and low-level solar characterization testing.

		Budget
Resources:	In-House FTE:	175K
	Subcontracts:	75K
	Total:	250K

2. Dish Receiver Technology

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

Rationale: Stirling dish-electric systems have been identified as having potential for meeting the Department of Energy (DOE) long-term energy cost goals. Dish-electric systems based on Stirling engine technology were successfully demonstrated by Advanco Corp. and McDonnell Douglas Corp. and operated at high efficiency (29%). To reach the ultimate potential for dish-electric systems, a high efficiency, low maintenance, and low cost receiver is required. The current thrust is to improve the longevity and reduce the O&M costs of receivers, as well as to improve performance. Based on earlier experience and analytical/experimental studies, the basic receiver type believed best suited for making these improvements is the reflux receiver. The reflux receiver is an optimum match for the Stirling engine's capability and requirements. In addition, reflux heat-pipe and reflux pool-boiler receivers may be applied to other solar thermal applications, with significant life and performance advantages over conventional tube receivers. In the longer term, other concepts for receivers may hold the promise for lower cost and increased reliability without the use of liquid metals. Some of these concepts are being proposed by industrial organizations interested in commercialization of dish/Stirling systems.

FY90 Accomplishments: Activities in this area were driven primarily by the needs of industry. The program was able to quickly and effectively respond to many commercially-generated requests over the course of the fiscal year. Specific accomplishments were:

- Provided extensive technical support in areas of heat-pipe reflux receiver design, test, and system integration to Cummins Engine Company and their subcontractors in the course of their 5-kW dish-electric commercialization efforts.
- Developed and demonstrated, at the bench scale, high-performance, screen-wick heat-pipes.
- Transferred to Stirling Thermal Motors the technology for use in 75-kW_t heat-pipe reflux receiver design and fabrication.
- Supported Stirling Technology Company in development of a 75-kW_t pool-boiler reflux receiver for the Advanced Stirling Conversion System.
- Concluded successful testing of a full-scale reflux pool-boiler solar receiver on-sun, and validated the high performance potential of the reflux receiver concept.
- Developed greater experimental capabilities (wick capillary capability, porosity and pumping height measurement; infrared thermography and X-ray measurement) for evaluating performance and supporting tests of full- and bench-scale reflux receivers.

FY91 Task Description: Work with the private sector will continue to develop the reflux receiver through analytical, design, and experimental activities and to investigate advanced concepts for receivers. The following specific efforts are planned:

- Initiate long term life bench testing of selected reflux receiver materials and fabrication samples.
- Conduct short term bench tests of three pool-boiler liquid metal enhanced boiling surface coupons.
- Fabricate and initiate on-sun testing of the next generation pool-boiler receiver.
- Develop two solar/fossil hybrid reflux receiver preliminary designs.
- Conclude a sintered-powder-wick receiver durability test in cooperation with industry.
- Evaluate, in cooperation with Stirling Thermal Motors, screen wick heat-pipe receivers.
- In conjunction with industry, evaluate advanced receiver concepts.

Major Milestones:

Jan 1991	Initiate Cummins/Thermacore heat-pipe receiver durability testing.
May 1991	Complete short-term, bench-scale, pool-boiler testing to finalize design parameters for second-generation full-scale pool boiler.
Sep 1991	Initiate long term pool-boiler bench testing to assess lifetime issues.
Sep 1991	Complete installation and checkout and initiate on-sun testing of the next-generation pool-boiler receiver.

Resources:

	Budget
In-House FTE:	998K
Subcontracts:	485K
Total:	1483K

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.

Rationale: Stirling engines have been identified as the most efficient power conversion unit currently available for solar-electric systems. With a demonstrated net efficiency of 29%, a dish-Stirling engine system holds the record for solar-to-electric power conversion. These engines range in power levels from 3 to 50 kW_e and are suitable for small-modular solar systems designed to produce electric power either for use in stand-alone applications or for delivery directly to the utility grid. In addition, Stirling engines used in a solar power system can be hybridized to run on both solar energy and fossil fuel so that power can be produced during periods of low solar insolation.

Several U.S. companies are developing Stirling engines for applications such as heat pumps, auxiliary power units, and transportation. Therefore, development costs for Stirling engines are financed primarily by non-solar applications. U.S. manufacturers are following the technology closely in order to be in the position to quickly begin manufacturing when technology and market conditions are appropriate.

FY90 Accomplishments:

- Provided extensive technical support to Stirling Thermal Motors on design, fabrication and operation of gas-fired liquid metal heat transport systems.
- Completed design of a tube/screen-wick gas-fired sodium evaporator.
- Through a DOE/NASA interagency agreement, completed the preliminary design of a free-piston Stirling engine- based solar electric system (designated as the Advanced Stirling Conversion System) and initiated the final design.

FY91 Task Description: Test and evaluate the performance of the Stirling Thermal Motors (STM) 25-kW kinematic engine in a test cell and complete preparations for on-sun testing. Complete the preliminary design of one Advanced Stirling Conversion System (ASCS) and the final design of another. The following specific activities are planned:

- Conclude test cell evaluation of the STM4-120, 25kW kinematic engine.
- Demonstrate performance of the Sandia-designed tube/screen-wick gas-fired evaporator.
- Conclude system and component integration activities to allow on-sun testing of the STM-120 with a reflux receiver mounted on a Test Bed Concentrator.

Major Milestones:

Feb 1991	Complete evaluation of the Sandia tube/screen-wick gas-fired evaporator.
Mar 1991	Complete final design of the Stirling Technology Company ASCS.
May 1991	Complete preliminary design of the Cummins/Sunpower/Thermacore ASCS.

		Budget
Resources:	In-House FTE:	525K
	Subcontracts:	1545K
	Total:	2070K

SECTION III

FY 1991 RESOURCE SUMMARY

Total baseline program resources available in FY91 consist of $11,561K in new budget authority (including $75K in capital equipment funds). Table III-1 shows the allocation of these resources by program activity. Table III-2 shows the breakdown between the laboratories and the program budget at the task level.

TABLE III-1. FY90 SOLAR THERMAL PROGRAM BUDGET SUMMARY

($ In Thousands)

PROGRAM ACTIVITY	BUDGET
I. COMMERCIAL APPLICATIONS	
A. CENTRAL RECEIVER COOPERATIVE PROJECTS	642
B. DISH/ENGINE COOPERATIVE PROJECTS	1963
C. PARABOLIC TROUGH COOPERATIVE PROJECTS	750
D. DESIGN ASSISTANCE	453
II. TECHNOLOGY DEVELOPMENT	
A. CONCENTRATOR TECHNOLOGY	3124
B. POWER CONVERSION	3803
CAPITAL EQUIPMENT	75
TOTAL	10810
DOE/HQ AND SAN	751
TOTAL	11561

(Rev. 2/26/91)

TABLE III-2. FY91 SOLAR THERMAL ELECTRIC PROGRAM FIELD LABORATORY BUDGET DETAIL

($ in Thousands)

PROGRAM ACTIVITY	SANDIA FTE	SANDIA In-House	SANDIA Contract	SANDIA Total	SERI FTE	SERI In-House	SERI Contract	SERI Total	FTE	LABS TOTAL Dollars
I. COMMERCIAL APPLICATIONS										
A. Central Receiver Cooperative Projects	1.4	240	350	590	0.3	52	0	52	1.7	642
B. Dish/Engine Cooperative Projects	2.1	375	1500	1875	0.5	88	0	88	2.6	1963
C. Parabolic Trough Cooperative Projects	0.8	130	550	680	0.4	70	0	70	1.2	750
D. Design Assistance	1.2	217	183	400	0.3	53	0	53	1.5	453
II. TECHNOLOGY DEVELOPMENT										
A. Concentrator Technology	5.3	928	1172	2100	4.6	804	220	1024	9.9	3124
B. Power Conversion	9.2	1610	1905*	3515	0.5	88	200	288	9.7	3803
SUBTOTALS	20.0	3500	5660	9160	6.6	1155	420	1575	26.6	10735
CAPITAL EQUIPMENT				38				37		75
LAB TOTAL				9198				1612		10810

*Includes 1035K NASA/LeRC/ASCS

SECTION IV

MANAGEMENT AND IMPLEMENTATION PLAN

1. PROGRAM MANAGEMENT

The management and direction of the Solar Thermal Electric Program is structured to be responsive to national energy policy. That policy is provided by the Secretary of the Department of Energy and incorporates recommendations from the Executive Office, the Congress, national energy advisory boards, other government agencies, industry, universities and others. Sound management of the program is essential to ensure that the overall goals of the Solar Thermal Electric Program are appropriate and are met and that the activities leading to those goals proceed in an orderly, cost-effective manner.

Implementation of the Solar Thermal Electric Program, as defined by the Multi-Year Program Plan, legislative requirements, resource availability, and the Annual Operating Plan, requires careful tracking of research and development activities to assure satisfactory progress toward the overall program goals. Milestones and decision points are established for each program task and are used to determine the necessity for redirecting activities in view of program priorities and available program resources.

Solar Thermal Program Management and Organization

The DOE Solar Thermal and Biomass Power Division is one of two divisions reporting to the Office of Solar Energy Conversion under the Deputy Assistant Secretary for Utility Technologies. The Division is responsible for managing and reporting the status and progress of the Solar Thermal Electric Program. Policy formulation, planning, resource allocation, and evaluation activities are performed by the Solar Thermal and Biomass Power Division. DOE operations offices and field laboratories have been assigned responsibility for implementing the program.

Field Laboratory Management and Organization

Specific implementation of the Solar Thermal Electric Program is assigned to two field laboratories, Sandia National Laboratories (SNL) in Albuquerque, New Mexico, and the Solar Energy Research Institute (SERI) in Golden, Colorado. Together, these two field laboratories are responsible for implementation of the technology development activities and the specific commercial applications 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.

SNL is the Solar Thermal Electric Program's lead laboratory. The program's management structure is shown in figure IV-1.

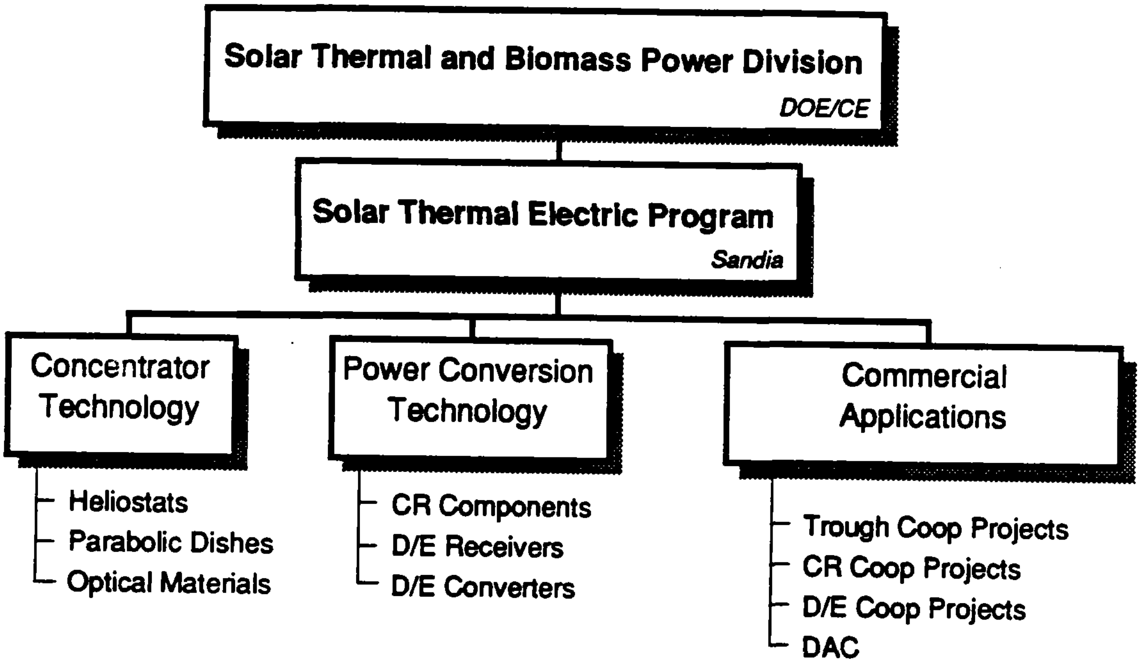

FIGURE IV-1

2. REPORTING

The DOE Solar Thermal Electric Program management is kept informed of program progress and management issues on a continuing basis through a variety of formal and informal means such as site visits, frequent telephone communication, weekly highlights, SOLTECH 91, quarterly reports jointly issued by SNL and SERI, periodic program reviews, and other topical meetings. The Quarterly Status Report is the primary formal mechanism for documentation of program progress, current planning, budget status, and other relevant management information.

3. TECHNOLOGY TRANSFER

The Solar Thermal Electric Program supports a number of technology transfer related activities to insure the prompt, accurate, and continuous flow of significant research and technology development information to industry and other users. The primary technology transfer conduit is through Commercial Applications. The interactive nature of these joint industry/government activities makes frequent transfer of relevant technology an essential feature of this portion of the program. Weekly newsnotes will provide first-level documentation of this technology transfer. The Solar Thermal Design Assistance activity is the program element which reaches the largest number of current and potential users/suppliers of commercial solar thermal electric technology. This design assistance activity is documented by the Solar Thermal Design Assistance Center monthly summary.

More traditional means of technology transfer are also employed. Topical reports/publications are periodically prepared and distributed to indicate the status of the solar thermal electric technologies and projects. Technical reports and papers on all aspects of the program's R&D are published and widely distributed. Technical reports are submitted to the DOE Technical Information Center (TIC) at Oak Ridge, Tennessee, for entry into the national data base on energy technology, and for sale by the National Technical Information Service (NTIS). Sandia and SERI also make limited immediate distribution of technical reports to targeted industry, laboratory, and university representatives.

Each year, several meetings/workshops are conducted to bring interested organizations, as well as researchers, scientists, engineers, and users together in a technical forum to exchange technical and programmatic information. DOE and the labs also participate in International Energy Agency (IEA) meetings and workshops. Industrial and end user representative and foreign and domestic researchers/scientists/engineers are encouraged to visit the field laboratories, solar thermal project sites, and test facilities to exchange information and ideas. At a minimum, these meetings, workshops and visits will be documented by weekly newsnotes. Continuing academic and industry involvement through postdoctoral, sabbatical, visiting scientist, summer faculty, and student programs afford the opportunity for first-hand interactions with laboratory staff and facilities. Direct involvement in conducting significant portions of the R&D work through subcontracts to universities and industry offers a direct avenue for technology transfer and participation with the solar thermal community.

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