Distributed Receive
Development Plan FY88–FY89

Sandia National Laboratories
Albuquerque, New Mexico

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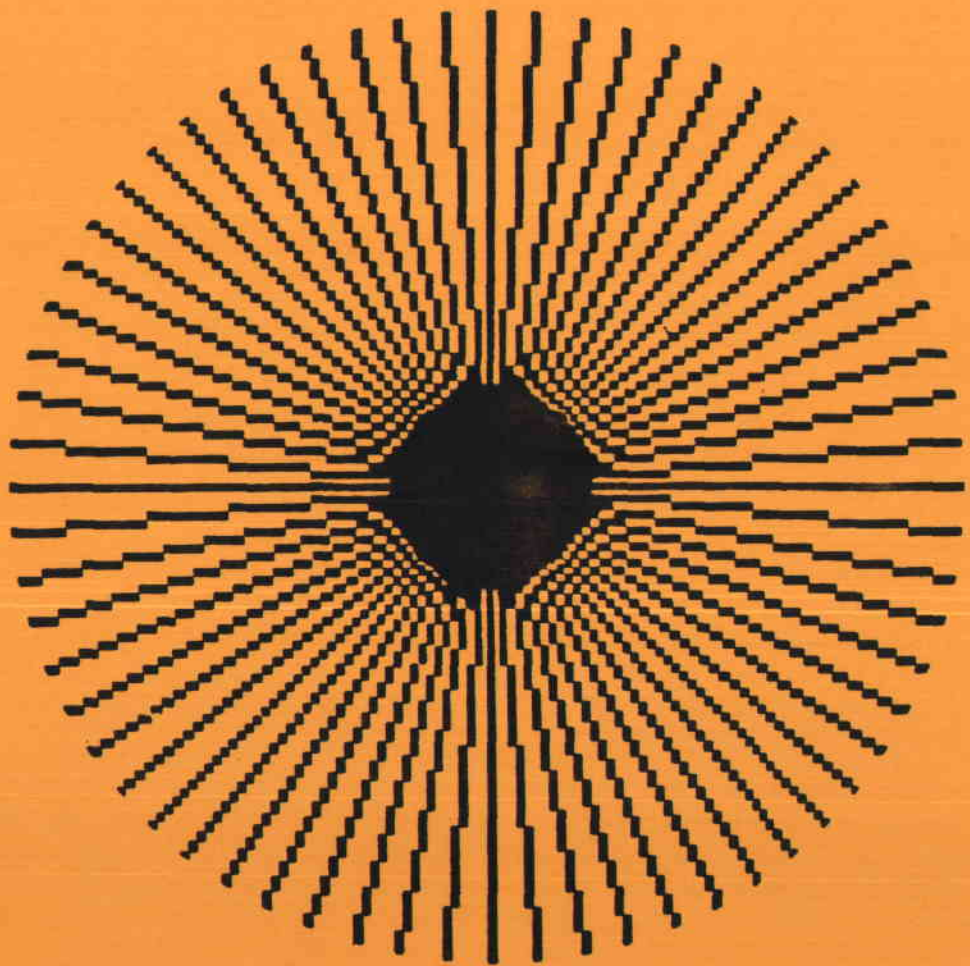

Department of Energy
Solar Thermal Technology Program

DISTRIBUTED RECEIVER DEVELOPMENT PLAN

1988-1989

Solar Energy Department
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CHAPTER 1. INTRODUCTION

The detailed program planning for the Department of Energy's (DOE's) Solar Thermal Technology Program is performed annually by two major field laboratories, SNLA and SERI, and by two DOE operations offices, AL and SAN. These four organizations each prepare and publish their individual planning documents describing detailed plans for the succeeding 2 fiscal years so that the research and development (R&D) activities for any year are defined at least a year in advance and revisions can be made in an orderly and timely manner. This document is the detailed program plan for SNLA's Solar Thermal Distributed Receiver Project for FY88 and FY89.

So that this plan may be viewed in its proper context, a summary of the DOE Five-Year Research and Development Plan[1] is presented in Chapter 2.

Chapter 3 presents the detailed plans for SNLA's distributed receiver development projects. Each activity is identified by a task number that directly correlates with the task numbers defined in the DOE Five-Year R&D Plan. The description of each task includes an explanatory narrative text and resource requirements (manpower and funding).

Chapter 4 provides summary information of SNLA's FY88 and FY89 Solar Thermal Distributed Receiver Projects Plan in several formats: a compilation of major milestones, a summary of resource requirements, a description of the management plan, a listing of proposed contracted procurements, and the organizational structure and key personnel within SNLA.

[1] "National Solar Thermal Technology Program: Five-Year Research and Development Plan, 1986-1990," DOE/CE-0160, U.S. Department of Energy, Office of Conservation and Renewable Energy, September 1986.

CHAPTER 2. THE DOE FIVE-YEAR SOLAR THERMAL TECHNOLOGY PROGRAM AND PLAN

This chapter summarizes the DOE Solar Thermal Technology Program as described in the Five-Year Plan.

The purpose of the Solar Thermal Technology Program is to develop an alternative source of energy based on collection and conversion of solar energy. To do this, the program supports research and development to improve cost and performance and to broaden areas of applicability for solar energy. This work complements the work of private industry and will provide technically proven systems for incorporation into the nation's energy supply industry.

The major obstacles to industrial and commercial use of solar energy are (a) high cost, (b) lack of performance verification, (c) unproven system reliability and life, (d) perceived technical and financial risk due to lack of operational experience, and (e) uncharacterized operations and maintenance costs. The major activities of SNLA's program focus on these issues.

Implementation of the Solar Thermal Technology Program is carried out through SNLA and SERI. SERI is responsible for research of materials and innovative concepts for solar thermal technology. SNLA is responsible for design and development of solar thermal distributed receiver and central receiver technology, including fabrication, testing, and evaluation of components, subsystems, and systems for production of electricity and industrial process heat, cogeneration, and fuels and chemicals production. The organizational structure is shown in Figure 2.1.

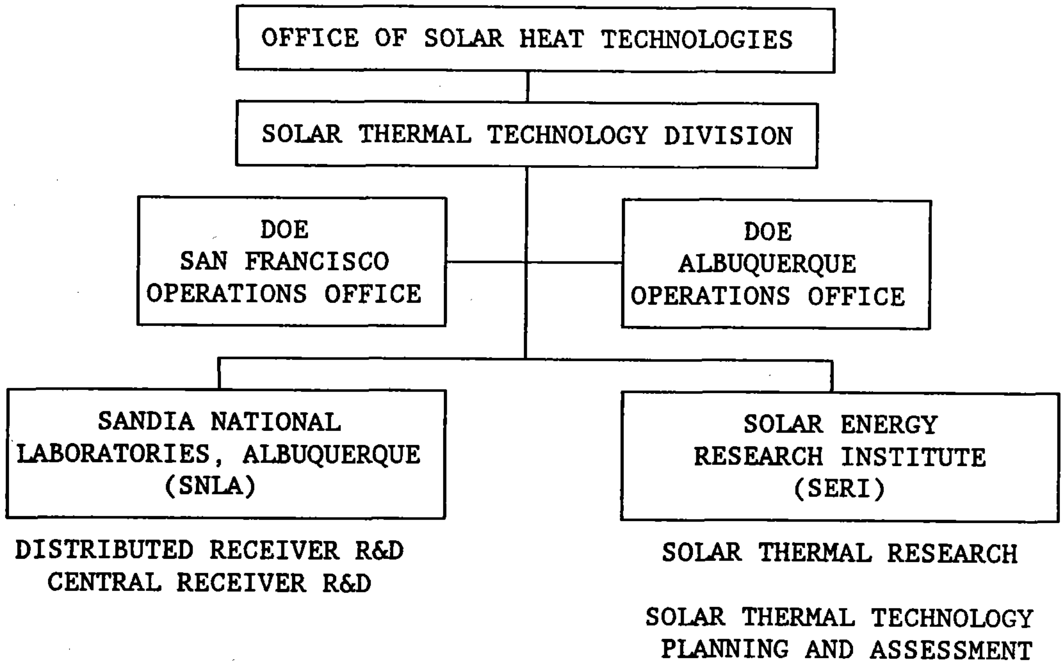

Figure 2.1. Solar Thermal Technology Organizational Structure and Responsibilities

The Solar Thermal Technology Development Program is divided into three broad categories: (1) Collection Technology, (2) Energy Conversion Technology, and (3) Systems and Application Technology. These categories are subdivided into 11 major R&D Tasks, which are listed and defined in Table 2.1.

Table 2.1. The Major R&D Tasks of the DOE Solar Thermal Technology Program

R&D Task	Definition
COLLECTION TECHNOLOGY	
1. Optical materials	Development of materials for the reflective and refractive surfaces of concentrators or the transmissive and absorptive components of receivers
2. Concentrators	Development of heliostats, dishes and troughs, (not including receivers)
3. Receivers	Development of components that convert solar radiation to thermal or chemical energy
ENERGY CONVERSION TECHNOLOGY	
4. Heat engines	Development of components that convert thermal energy to electricity or shaft power through thermodynamic processes
5. Direct conversion	Development of components that convert solar radiation to electricity or chemical energy without the use of a heat engine
6. Transport and storage	Development of components that convey energy to the point of use or allow delay of its use
SYSTEMS & APPLICATIONS TECHNOLOGY	
7. Innovative concepts and applications	Entry point activities for promising component and system concepts that constitute major departures from conventional solar thermal technology
8. Balance of plant	Development, characterization, and optimization of other components, particularly controls, necessary to construct and operate a complete solar thermal facility
9. Central receiver systems	Activities related to the analysis and development of central receiver applications on a system level

Table 2.1. (continued)

R&D Task	Definition
10. Distributed receiver systems	Activities related to the analysis and development of distributed receiver applications on a system level
11. System experiments	Activities related to the design, construction, start-up, operation, and testing of solar thermal installations

System-level planning targets expressed in terms of annual efficiency, capital costs, and energy cost have been developed to meet the need for quantitative program goals. These targets are used to provide direction for R&D planning activities, to measure progress, to assess alternative technology options, and to make rational component decisions. The system-level targets for solar thermal technologies as presented in the Five-Year Plan are summarized in Table 2.2 for plants producing electricity and for plants producing heat. The long-term prospects for solar thermal technologies attaining the system goals must be judged on the basis of systems analyses, cost projections, and data from operating systems.

Table 2.2. Solar Thermal Technology Long-Term Targets

Characteristic	System Product	
	Electricity	Heat
System annual efficiency	22%-28%	56%-68%
System capital cost[a]	\$1000-1200/kW_e	\$270-430/kW_{th}
System capacity factor	0.26-0.5	0.24-0.29
System energy cost[b]	\$.04-.05/kWh	\$7-9/MBtu

[a] Normalized to engine or process capable of handling peak field thermal output; includes indirect costs; 1984 $.

[b] Energy costs levelized in real dollars; economic assumptions differ between electric and heat systems; 1984 $.

To date, the efforts of industry and the federal government have led to steadily decreasing energy costs from solar thermal systems. Continuing evolution of system components and designs will further reduce costs and increase the number of economically attractive applications. As the manufacturing production rates for solar components gradually rise, production costs will decrease, contributing to further improvements in the economics of solar thermal energy.

CHAPTER 3. DISTRIBUTED RECEIVER DEVELOPMENT PROJECT PLAN, FY87 AND FY88

The primary area of responsibility for SNLA's Solar Thermal Projects is distributed receiver component and systems development. This is reflected in the Task and Subtask structure in Table 3.1, which indicates that, during FY88 and FY89, SNLA proposes to participate in eight of the eleven major tasks described in the DOE 5-Year Plan. The remainder of this chapter contains the detailed R&D plans for FY88 and FY89 for each task and subtask in the SNLA Distributed Receiver Development Project.

Table 3.1. SNLA Distributed Receiver Project Subtask Structure

Task 1. OPTICAL MATERIALS
- Subtask 1.1 Silver Sol-Gel Mirror
- Subtask 1.2 Optical Measurements Lab

Task 2. CONCENTRATORS
- Subtask 2.1 Line-Focus Concentrators
- Subtask 2.2 Point-Focus Concentrators
- Subtask 2.3 DRTF Support

Task 3. RECEIVERS
- Subtask 3.1 Receiver Analysis
- Subtask 3.2 Receiver Development
- Subtask 3.3 DRTF Support

Task 4. HEAT ENGINES
- Subtask 4.1 Heat Engine Analysis
- Subtask 4.2 Stirling Engine Development
- Subtask 4.3 DRTF Support
- Subtask 4.4 Thermal Electric Converters

Task 6. TRANSPORT AND STORAGE
- Subtask 6.1 Code Development
- Subtask 6.2 Thermochemical Transport Development
- Subtask 6.3 Field-Scale Thermochemical Experiment
- Subtask 6.4 DRTF Support

Task 8. TRANSPORT AND STORAGE
- Subtask 8.1 Control Systems Development

Task 10. DISTRIBUTED RECEIVER SYSTEMS
- Subtask 10.1 Systems Engineering and Analysis
- Subtask 10.2 Distributed Receiver Test Facility
- Subtask 10.3 Shenandoah STEP Evaluation

Task 11. SYSTEM EXPERIMENTS
- Subtask 11.1 Small Community Solar Experiments

R&D TASK 1, OPTICAL MATERIALS

The development of optical materials for solar applications has a major impact on concentrator development. Although SERI has the principal responsibility in the Solar Thermal Program for research on materials, mirrors, absorber coatings, etc., Sandia is involved in optical materials development in areas where it has special expertise and where specific, well-defined component applications exist.

A major development in optical materials in which Sandia has taken the lead role is in the development of sol-gel for various concentrator applications. Over the past 2 years the sol-gel process has encouraged the development of the silver-stainless structural mirrors. The sheet metal mirror has the advantage that it can be self-supporting and can also withstand the loads imposed by wind and gravity. The sol-gel process has made it possible to develop a high-quality silver-on-stainless mirror by acting as a dielectric insulator that can prevent galvanic corrosion. At the same time a protective coating of sol-gel over the silver reflective surface has made it possible to take advantage of the inherently high reflectivity of silver. Steel mirrors with a reflectivity of 94% within a 15-mr cone angle have been successfully constructed. In FY87 the development of stainless steel mirrors made of thin foils was initiated. The intent of this effort is to eventually apply these foil mirrors to stretched membrane concentrators applicable to dishes and heliostats. The thin foil mirror development will continue through FY88 with the process optimized in early FY89. Testing of sol-gel processed foil mirrors in the 3- to 5-mil range is anticipated for FY89.

The transfer of technologies developed under government funding to industry is an essential element of the process. An effort will be initiated in FY88 to transfer the sol-gel technology to an industrial contractor. This will assure the DR project a supplier of reflective material in moderate quantity in support of R&D activities and also provide a source for near-term commercial applications.

Sandia will continue to maintain the facilities and activities of the Optical Measurements Laboratory. In addition to the development of optical measurement equipment and methods, an important mission of this laboratory is to provide optical testing of reflective materials developed for concentrator systems by industry and other agencies such as NASA. In conjunction with this service the necessary environmental testing, accelerated as well as real-time, will be provided when these are required in conjunction with the services of the Optical Testing Laboratory.

<u>Resource Requirements, Task 1</u>

Costs (k$)	FY88	FY89
In-house	208	391
Contracts	50	260
Total costs (k$)	258	651
Manpower (man-yr)	1.3	2.3

R&D TASK 2, CONCENTRATORS

The solar collector is the system component that concentrates the sun's energy at a location where it can be practically used as a "high quality" heat source. Efficient, economical solar concentrators are critical for the success of high temperature, solar thermal systems. The purpose of the Concentrator Task is the development of high-performance, low-cost solar concentrators to serve as energy source for thermal processing and electrical power generation.

The solar concentrator task at SNLA is divided into two major areas defined by the geometric configuration of the solar collector; these subtasks are line-focus and point-focus concentrators. The development of heliostats, a solar concentrator used in central receiver systems, is the responsibility of Sandia's Central Receiver Division.

Status and Planned Activities

Subtask 2.1 -- Line-Focus Concentrators

Activities in the Line-Focus Concentrators Subtask have been limited to the evaluation, at the Distributed Receiver Test Facility (DRTF), of components aimed at improving the performance, operation or maintenance of a generic system. These evaluations are pursued on a not-to-interfere basis with other Task 2 activities, and the results are published as they become available. No budget is allocated to this subtask.

Subtask 2.2, Point-Focus Concentrators

Two major program activities--the Innovative Concentrator Project, and the Stretched-Membrane Dish Concentrator Development Project--constitute the Point-Focus Concentrator Subtask.

Sandia provides technical and management support to the DOE/AL administered Innovative Concentrator Project. Contractors in this project completed Phase I detailed design by demonstrating the fabricability of their respective optical elements and presenting their detailed collector designs in FY86. The Acurex Corporation and LaJet Energy Company completed the fabrication of their collectors and delivered them to Sandia's Distributed Receiver Test Facility (DRTF) for assembly and testing in FY87.

The Acurex Innovative Concentrator design utilizes thin sheet metal stamped to form the rigid parabolic substructure of the dish. Additional sheets of steel with ECP 300 silver film applied to the front surface are bonded to the stamped substrate to form the optical surface of the concentrator. The Acurex collector was severely damaged during a windstorm in December of 1986. The cost to repair the collector would have been very high and, since there are no provisions for adjusting the contour and the optical film has degraded through a tunneling delamination process; the dish has been disassembled and salvaged.

The LaJet Energy Company Innovative Concentrator is comprised of 95 stretched membrane, facets made with silver polymer film and utilizes a polar-mounted, tracking/drive system. The collector was delivered to the DRTF and assembled in July and August of 1987, nearly 7 months behind schedule, because of delays in the delivery of the optical film and collector testing in Abilene. The LaJet collector is scheduled for testing at the DRTF during the third and fourth quarters of FY88.

In FY87 Sandia initiated a project to apply the stretched-membrane approach to the development of a large facet, point-focus solar collector. The thrust of this initiative is the development of a lightweight, high-performance solar collector. The project is organized into two phases: Phase I is the design of an optical element and Phase II is the detailed design of the balance of the collector system, construction and testing of the collector. Phase I contracts were placed with Solar Kinetics, Inc. (SKI) of Dallas, Texas, and the LaJet Energy Company of Abilene, Texas, during the first quarter of FY87. Phase II will begin during the third Quarter of FY88 and will require about 2 1/2 years to complete. The major milestones of Phase II of the Stretched Membrane Dish Development Project are: a topical report on the fabrication issues associated with the membranes, such as metal and polymer seams, and repeatability of the fabrication process; the construction and testing of an intermediate scale optical element to further evaluate issues associated with scale; and the design and fabrication of a full-scale solar collector that will be tested at the DRTF. Budget limitations dictate the selection of only one of the Phase I contractors for Phase II of the project.

The existence of a high-performance sheet metal solar collector could encourage near- to mid-term marketing efforts by industry. The sheet metal collector represents a reasonable extension to current dishes as well as a more conventional manufacturing approach to concentrator design. Sandia will issue a request for industry cost-shared proposals in FY89 for a cost-shared project to develop a dish-engine module using a sheet metal collector and a Stirling engine. Sandia will provide the testing and evaluation of the module.

<u>Resource Requirements, Task 2</u>

Costs (k$)	FY88	FY89
In-house	457	595
Contracts	975	1500
Total costs (k$)	1432	2095
Manpower (man-yr)	2.8	3.5

R&D TASK 3, RECEIVERS

The receiver is a key component of a distributed solar thermal power system. Its design must meet the requirements imposed by the concentrator and the power conversion or thermal process subsystem.

The long-term goal is to develop receivers with 90% to 95% annual efficiencies that can be manufactured for \$30 to \$40/m² of concentrator aperture area (see

Five-Year Plan). The objective of this task for FY88 and FY89 is to continue to develop the analytical and experimental tools and techniques necessary to design efficient receivers, to make cost-effectiveness trade-offs, and to build and test prototypes to evaluate receiver performance.

Plans for the next 2 years are to:

- o Continue to develop analytical (computer modeling) tools for receiver design analysis.
- o Develop an understanding of receiver performance via modeling, building and operating prototype receivers, and receiver experimentation to measure performance and reliability.

These activities will be directed toward developing receivers for dish-electric applications.

Status and Planned Activities

Subtask 3.1. Receiver Analysis

Receiver design computer codes have been and will continue to be the cornerstone of the receiver task. The CIRCE code that was made operational in 1986 and validated in 1987 will be expanded to support receiver development activities under Task 3.2. Thermal analysis models will be developed and will continue to integrate the concentrator with the receiver and thermal loads. The primary emphasis will be placed on supporting reflux receiver development activities in Task 3.2. Codes will be validated with existing receiver data, data taken from receivers under development, and with data taken from experiments specifically designed to explore receiver thermal loss mechanisms. Previously developed experimental devices for the measurement of flux and temperatures in receivers will be used extensively for these experiments. An important objective of this effort is to develop a fundamental understanding of energy loss mechanisms and design guidelines for minimizing them.

Subtask 3.2. Receiver Development

The "reflux" receiver concept has been identified as a potentially attractive receiver option for kinematic and free-piston Stirling engines, LMTEC, and thermochemical energy transport. The reflux concept is attractive because it separates the engine heat exchanger from the solar flux, allowing the evaporator shape to optimize the collection of solar energy and the condenser to be configured to suit the particular application. The reflux concept also promises simple, low-cost, reliable, and efficient receivers and readily permits fossil fuel hybridization. The near-isothermal operating characteristics of reflux receivers also reduces the potential for excessive thermal stresses that have caused problems in conventional tube receivers. A contract was placed in FY87 with Stirling Thermal Motors Inc. (STM) for a screened wick reflux heat-pipe receiver to operate the STM4-120 engine. STM has completed a receiver design and their first prototype will be constructed and delivered to Sandia in September 1988. After acceptance inspection, a receiver-only calorimeter test will be conducted early in FY89. A second receiver will be mated with the STM4-120 engine in FY89. Prior to mating with the receiver, the STM4-120 engine will be bench tested with gas combustor heat pipes, also supplied by STM (see Task 4).

Conceptual designs of free-piston Stirling engines have identified several alternatives to the screened-wick evaporator reflux heat-pipe receiver. These include a "pool boiler," in which the sodium inventory covers the evaporator, and a wick structure of sintered powder. Alternate working fluids have also been identified. SNLA will investigate alternatives in early FY88 and design and build prototype receivers by October 1988. The receivers will mount to the DRTF's Test Bed Concentrator (TBC) and will be capable of interfacing with the STM4-120. Based on results of the TBC on-sun tests, a preferred approach will be selected and a second generation receiver will be built by late FY89 designed for the TBC and the selected free-piston Stirling engine.

During FY88 and FY89, general reflux receiver concerns will be investigated at the component level, including long-term material compatibilities, stress analysis, wicking, and cavity design.

Direct catalytic absorption receiver/reactor (DCAR) concepts will also be developed under an International Energy Association's (IEA) annex. The project, called Catalytic Enhanced Solar Absorption Receiver (CAESAR), will be tested in Germany in the summer of 1989. The DCAR concept being developed for CAESAR is of interest for receiver/reactors because absorption of concentrated sunlight directly on a catalytic matrix has the potential to circumvent flux limitations inherent in conventional reactors and is a solar unique capability. An objective of the Receiver Task will be to complete an analytical technical assessment of the feasibility, performance, and cost advantages of this approach by the second quarter of FY88. In addition, exploratory experimental studies with DCARs will be initiated in the Sandia 7-meter solar furnace facility at the DRTF to support the CAESAR activities.

Other receiver concepts will be investigated where appropriate. Tube receivers, e.g. ORC and Shenandoah, will be operated and modeled to gain a better understanding of thermal loss mechanisms.

<u>Resource Requirements, Task 3</u>

Costs (k$)	FY88	FY89
In-house	758	646
Contracts	238	900
Total costs (k$)	996	1546
Manpower (man-yr)	5.1	3.8

R&D TASK 4, HEAT ENGINES

The objectives outlined for this task are the evaluation and development of heat engine technologies applicable to Distributed Receiver Systems. The development of small, low-cost, efficient, long-lived heat engines are of the utmost importance to the dish-electric concept. The Solar Thermal Five-Year Plan cites the need for engine performance and cost in the long term to be 41% annual efficiency and \$300/kW$_e$ to support the system-level goal of \$0.05/kWh. Alternate combinations of cost and performance that provide equivalent cost-effective results would, of course, be acceptable.

Task 4 has been organized into four subtasks: Heat Engine Analysis, Stirling Engine Cycles, Thermal Electric Converters, and DRTF Support. The primary R&D activities in the past few years have involved the dish-electric concept in which a heat engine and generator are located at the focus of a parabolic dish concentrator for heat-to-electric energy conversion. These activities will continue to be the main thrust of the project. Conceptual studies, designs, hardware development, and testing will take place during FY87 and FY88 through both in-house activities and contracts.

Status and Planned Activities

Subtask 4.1, Heat Engine Analysis

The objective for the Heat Engine Analysis subtask is to analyze advanced energy conversion devices that show potential for development and for meeting program goals in the mid and long term. Computer codes developed at SNLA can support analyses and trade-off studies of performance and economic capabilities. SNLA will continue to upgrade and utilize its library of programs to analyze heat engines for Distributed Receiver Systems. For example, SNLA recently acquired the computer code GLIMPS from Gedeon Associates to analyze Stirling Thermal Motors (STM) kinematic Stirling engine STM4-120. This code will generate performance predictions which can be compared to the actual measured performance for this engine.

Subtask 4.2, Stirling Engine

Considerable progress was made in the research and development of free-piston Stirling engines (FPSE) in FY87. The FPSE is attractive for the dish-electric concept because it offers the potential of high reliability, long life, low maintenance, and high cycle efficiencies. Contracts were awarded, through NASA/LeRC, to Stirling Technology Co. (STC) and Mechanical Technology Inc. (MTI) for a conceptual design of a solarized FPSE. Completed designs were delivered in the third quarter of FY87. Pioneer Manufacturing and Engineering conducted a cost-to-manufacture study based on both designs in the fourth quarter of FY87. During the first quarter of FY88, SNLA and NASA/LeRC will review both design concepts along with Pioneer's cost analysis. Based on one design or a combination of both, one or more competitive contracts will be let through NASA/LeRC for a preliminary design, detailed design, fabrication and testing at SNLA's Engine Test Facility (ETF) and then on the Test Bed Concentrator (TBC). The schedule to deliver an engine for testing at SNLA is based on the level of funding; however, completion is scheduled for late FY90.

In FY86 SNLA placed a contract to buy a Stirling Thermal Motors (STM) STM4-120 kinematic Stirling engine. Due to development setbacks, delivery has been rescheduled for mid FY88. Once the engine has been delivered to SNLA, it will be installed in a test cell at SNLA's ETF. In this location, the engine will be integrated with a control system, gas combustion/heat pipe system, instrumentation, and a dynamometer. Performance mapping of the engine will be the first phase of testing at SNLA and will include power output determination, part load characteristics, torque and efficiency. In addition to performance measurements, an operation and maintenance schedule will be established for the STM4-120. The cost of operation and maintenance (O&M) is an important parameter in determining the viability of the Stirling engine for dish-electric systems. The second phase of testing of the engine in the ETF will be to simulate on-sun operation of the engine. These tests will help evaluate the responsiveness of the controls and engine to transients in heat input rate. Any adjustments required can be made prior to actual on-sun system testing on the TBC. For evaluating the engine on-sun, a reflux heat-pipe receiver will be interfaced with the engine (see Task 3). On-sun evaluation of the complete system is scheduled to begin in late FY89 and continue through FY90.

Beginning in FY89 a design study will be initiated to upgrade the STM4-120 to about 50-kW output and still maintain attractive life and performance. Actual hardware upgrade would be a future effort and would depend on concentrator size trends.

Subtask 4.3. DRTF Support

Testing of the first-generation organic Rankine cycle (ORC) developed by Ford and Barber-Nichols was initiated in FY86. Testing continued through FY87 and will be completed in FY88. The ORC will be retained at the DRTF to support the SCSE#1.

Bench testing of the STM4-120 will begin in the ETF in FY88. Characterization of the engine along with the ancillary equipment supplied by SNLA will be the main areas of testing. In late FY89 the STM4-120 and a heat pipe optical cavity receiver will be combined and mounted on TBC-1 for on-sun testing. Characterization will continue into FY90.

Resource Requirements, Task 4.1, 4.2 and 4.3

Costs (k$)	FY88	FY89
In-house	454	510
Contracts	702	1055
Total costs (k$)	1156	1565
Manpower (man-yr)	2.7	3.0

Subtask 4.4. Thermal Electric Converters

As a result of budget considerations, this task will undergo an orderly shutdown during the first and second quarters of FY88. The objective of this task has been to identify, analyze, and develop promising nonconventional energy conversion devices applicable to solar thermal systems.

The following paragraphs summarize the status of the LMTEC project at the time of shutdown. The Liquid Metal Thermal Electric Converter (LMTEC) has been identified as having the potential to meet the Solar Thermal Technology Program long-term cost and performance goals. With the absence of mechanical moving parts, the LMTEC has the potential for long life with a minimum of operation and maintenance costs. The LMTEC's thermodynamic cycle efficiency closely approaches that of the ideal Carnot cycle. An engineering assessment of the LMTEC for dish-electric applications has identified mercury as the working fluid with the best potential to meet the program's long-term goals. In addition, potassium has also been shown to offer significant performance advantages over sodium for dish-electric applications.

An essential element of the LMTEC is the Beta double-prime Alumina Solid Electrolyte (BASE) which conducts metal ions of the working fluid. The BASE is readily available for sodium as the working fluid and can be readily exchanged by established techniques for potassium. A mercury-based electrolyte is beyond current technology but progress in developing such an electrolyte was encouraging in FY87. Single crystals of Hg-BASE with close to 100% exchange had been produced by late FY87 at the University of Pennsylvania. Work with polycrystalline BASE material at the University of Wisconsin has achieved close to 20% exchange. With the growing understanding of the fundamental exchange mechanism for single crystals, it is expected that the exchange levels in the polycrystalline BASE will be rapidly enhanced. These two University contracts are expected to continue to yield important progress through their expiration late in the first quarter of FY88. Final reports are due by the end of the second quarter.

A preliminary design study at SNLA of the LMTEC for dish-electric applications has produced conceptual designs with several innovative features, including a unique configuration of the BASE material which allows the use of working fluids with higher vapor pressures, and a refluxing boiler, which would allow the internal series connection of the LMTEC cells without shorting through the working fluid. The first Bench Test Module (BTM-1), tested in FY87, produced much less power than desired and failed after several hours of operation at 800°C. However, this test established the feasibility of the internal bus bar/electrode configuration design, provided sufficient data to establish future hardware requirements, suggested alternate component level testing, and served to point out the critical role of electrode permeability.

The tungsten electrode used in BTM-1 was deposited by a chemical vapor process by a commercial supplier. Preliminary results from a new electrode evaluation technique indicate that this electrode was very impermeable--an undesirable characteristic. Increased emphasis was then placed on developing a molybdenum electrode deposited either by decomposition of an organo-metallic ink or by post-cathode dc magnetron sputtering. Preliminary results have been obtained by both methods in FY87, with electrical sheet resistance in the range of interest. Development efforts for both approaches will be brought to an orderly conclusion in the first quarter of FY88. The permeability of these electrodes will be evaluated during the first quarter of FY88, with documentation completed in the second quarter.

The new electrode evaluation technique referenced in the preceding paragraph was developed at SNLA. This measurement capability was beyond the state of the art at the project's inception but was needed for the straightforward development of permeable electrodes. Although initially the method was limited to electrodes not readily wet by sodium at 350°C, a modified apparatus that will avoid this limitation has been built and will be tested in the first quarter of FY88. The main advantage of this technique is the removal of the requirement for a fully assembled LMTEC to evaluate electrode performance. It will result in increased insight into electrode behavior, as well as savings in testing time and money. The modified apparatus will be used in a limited program to characterize existing electrodes on hand, and the technique will be documented in the second quarter of FY88.

Most of the work involved in the post-test analysis of BTM-1 has been completed in FY87. The one major area remaining to be completed is the extension of our electrode evaluation technique, which will enable additional characterization of the tungsten electrode used in BTM-1. The documentation of the design, operation, test results, and post-test analysis of BTM-1 will be completed during the second quarter of FY88.

<u>Resource Requirements, Task 4.4</u> (closeout only)

Costs (k$)	FY88	FY89
In-house	135	527
Contracts	20	300
Total costs (k$)	155	827
Manpower (man-yr)	0.8	3.1

R&D TASK 6, TRANSPORT AND STORAGE

The efficient transport and storage of thermal energy is critical to the development of parabolic dish system technologies. Present sensible heat transport methods at the medium to low temperature range (≤400°C) cost a significant percentage of the collected energy in transport (piping losses) to deliver the energy to the use point. Because of the very high temperature capability of parabolic dishes and the extensive piping required to deliver energy from a large collector field, low thermal-loss energy transport technology needs to be developed.

The objectives of this task are to identify, understand, and evaluate high-efficiency, low-cost energy transport and storage systems suitable for high-temperature (≥400°C) solar thermal distributed receiver applications. A primary candidate for low-loss energy delivery at these temperatures is the concept of thermochemical (TC) energy transport. The current emphasis of Task 6 activities is on developing and demonstrating the technology of TC transport for point-focus distributed-receiver, central-electric applications. The relevant long-term goals for transport systems (process heat) are 94% efficiency at 65 $/m^2$. The objectives of this task are being addressed through a program of complimentary computer modelling and experimental studies. The task is divided into four subtasks which reflect these activities.

Due to FY88 budget reductions and anticipated FY89 budget constraints, all activities within Task 6 are being brought to a logical conclusion in FY88. Only those high-value activities requiring a minimal amount of effort will be completed.

Status and Planned Activities

Subtask 6.1. Code Development

The code development activity is aimed at obtaining the necessary computational tools for making performance/economics evaluations of sensible and TC energy transport systems for distributed receiver applications.

The Closed Loop Efficiency Analysis (CLEA) code is a single-loop, steady-state performance model for TC energy transport based on the CO_2/CH_4 reforming/methanation system. CLEA code activities in FY87 consisted of support for the Task 10 Central Engine Study (see below) and documentation of the initial version of the code, designated 86.1. This documentation will be completed in FY88. Further development of the CLEA code is not anticipated at this time.

As part of the catalyst evaluation and development study being performed at the University of Houston (described in Subtask 6.2), two CO/H_2 methanation models and a closed-loop CO_2/CH_4 reforming/methanation model were provided to Sandia during FY87. Reactor modelling studies will continue in FY88 and will include development of more precise reaction kinetics models (including catalyst pellet kinetics and methanation with CO_2/CH_4, and water added to the feed) and extension of the models to direct catalytic absorption receivers in support of the CAESAR project.

Subtask 6.2. TC Transport Development

Experiments continued during FY87 in the CLEA TC energy transport facility at SNLA. This is a laboratory-scale (2.5 kW_{th}) facility based on the CO_2/CH_4 reforming/methanation chemical system. It is a single loop employing one reformer and one methanator that can be operated in open- and closed-loop configurations under steady-state or simulated solar conditions. The CLEA facility has provided critical data for the design of CLOE involving catalyst selection, materials concerns, and operating procedures.

In order to achieve higher conversion and better selectivity in the endothermic reaction and higher overall efficiencies, an endothermic reactor capable of reaction temperatures between 900 and 1000°C was designed and fabricated in FY87. Also, a two-stage methanator was designed and fabricated in FY87. The first stage is adiabatic and the second stage is isothermal. The high-temperature reformer and the new methanator have been installed and testing began in the fourth quarter of FY87. Experiments in the upgraded CLEA laboratory facility will be completed by mid FY88.

Catalyst evaluation and development studies have continued at the University of Houston in support of the CO_2/CH_4 TC transport system. Accomplishments in FY87 include 1) preliminary determination of rate equations, heat transfer parameters, and deactivation rates and mechanisms for rhodium-based catalysts in pellet form, and 2) modification of existing computer models to incorporate information obtained in Number 1 above. These models have aided in designing the reformers and methanator for the field-scale experiment (CLOE) and the 20-kW_{th} receiver/reformer to be tested at the Weizmann Institute (see Task 3). Catalyst development and reactor modeling studies in support of TC transport will conclude at the University of Houston in FY88. Planned activities include 1) refining the rate equations and heat transfer parameters discussed above, and 2) the model development activities described in Subtask 6.1.

Coking experiments were completed in FY87 to investigate carbon deposition on candidate reformer and methanator materials in representative gas environments (mixtures of CO, H_2, CO_2 and CH_4 at temperatures ranging from 400 to 900°C). Taken together, the results of these experiments had a major impact on the CLOE Phase I design.

Mechanical properties experiments to evaluate the creep and weldability characteristics of candidate alloys in representative CO_2/CH_4 reforming environments were completed in FY87. Creep-rupture, hot ductility, and welding fabrication tests were performed on Inconel 617. Based on the results obtained and on comparisons with the high-temperature mechanical properties of other alloys (Incoloy 800H, Manaurite 36X, and Manaurite 900B), Inconel 617 was selected as the primary construction material for the CLOE reforming reactor tubes. This completes the mechanical properties studies in support of CLEA and CLOE activities and no further experiments are planned for FY88.

Subtask 6.3. Field-Scale Closed Loop Operations Experiment

As a follow-up to the modeling and experimental activities described above, the next logical step in developing TC transport technology is to proceed to TC transport testing at larger than laboratory scale and under more realistic conditions. A field-scale experiment including multiple endothermic receiver/reactors (both conventionally and solar heated) and as many commercially available components as possible, would be a major step in demonstrating the practical feasibility of TC transport for solar applications.

As initially conceived, the Closed Loop Operations Experiment (CLOE), based on the CO_2/CH_4 reforming/methanation chemical system, would have been conducted in two phases. Phase I would have involved conservative, state-of-the-art receiver/reactor designs to ensure successful operation of the system and energy input to the system via electric heaters to obtain better control and more flexibility in performing the experiments. Phase II would have involved advanced receiver/reactor design concepts capable of operating at higher temperatures and at least one unit mounted on a parabolic concentrator in the DRTF to provide data and operational experience in a true solar environment.

An A&E contract for CLOE construction drawings and bid package preparation was placed with Black & Veatch in FY87. Early in FY88, all work directed toward the design and construction of the CLOE project will be brought to an orderly conclusion. The piping and instrument diagrams (P&IDs) will be finished by Black & Veatch. A final review of the drawings, equipment specifications, and operating procedures will be held during the first quarter FY88. This will document the CLOE Phase I accomplishments to date and provide a reference point in the event that the experiment is reactivated in the future. Additional contracted work with B&V was terminated.

Subtask 6.4. DRTF Support

Consultation and technical input by DRTF will be furnished to the A&E design contractor.

Resource Requirements, Task 6 (closeout only)

Costs (k$)	FY88	FY89
In-house	170	0
Contracts	80	0
Total costs (k$)	250	0
Manpower (man-yr)	1.2	0

R&D TASK 8, BALANCE OF PLANT

This task consists of R&D on all those elements of distributed solar thermal systems that are not specifically included in the other tasks. The most important area is that of development of appropriate controls, both for subsystems, such as collector tracking controls or receiver fluid controls, and for the entire system. Other balance of plant considerations include mechanical equipment, field wiring and protection, interfaces between solar systems and their applications, safety, etc.

Status and Planned Activities

The primary focus of the Balance-of-Plant (BOP) task is the development of economical and reliable control systems. A study of the current state-of-the-art control system hardware and strategies has been completed. A report on this study was completed in early FY87. With this background information, the requirements for distributed receiver control systems were evaluated. This assessment of controls development needs, as well as other balance-of-plant needs, was completed in FY87 and was documented in the form of a multiyear development plan.

Because of budget limitations, no FY88 activities are planned for the BOP task.

Resource Requirements, Task 8

Costs (k$)	FY88	FY89
In-house	0	0
Contracts	0	0
Total costs (k$)	0	0
Manpower (man-yr)	0	0

R&D TASK 10, DISTRIBUTED RECEIVER SYSTEMS

The purpose and goal of the system task is to develop the tools and expertise to provide guidance from the system level about performance and cost trade-offs, and to provide the means to investigate component interaction that can aid in directing component development. Toward that end, the capability is being developed for both parametric analysis and detailed systems analysis on a consistent basis that will be useful throughout the distributed solar thermal program. The majority of system studies fall into two major technological headings--dish electric and central engine. An additional study will evaluate the use of solar thermal systems for destruction of hazardous wastes.

Also, the activities of this task provide for the operation and maintenance of the Distributed Receiver Test Facilities (DRTF) and for analysis and evaluation of systems tests, in particular the Solar Total Energy Project at Shenandoah, Georgia.

Status and Planned Activities

Subtask 10.1. Systems Engineering and Analysis

The effort of FY87 concentrated on completing Phase II of the Central Engine Study. This study investigated the viability of using current Rankine technology for conversion (thus avoiding expensive engine development) along with one of two types of heat transport methods: sensible and thermochemical. Current engine technology in the 500-kW_e to 50-MW_e size range of Rankine engines was identified through a contract with Mechanical Technology Inc. The performance and cost of conversion using available technology was then used for simulation with the solar collection system. The sensible system considered involved the heating of liquid metal NaK in a field of 28-1836 dishes (depending on the plant design output). The performance of the field was approximated on a daily basis which in turn was extrapolated to predict annual performance. Minimum equipment to maintain purity was costed to account for known operation requirements with liquid metal systems. The thermochemical transport system was modeled using steady state design points superimposed onto varying insolation levels. Consistent with the level of detail in the sensible system, performance and cost data were gathered and included in a simulation model with the conversion cycle model to obtain estimates of levelized energy costs. The results of Phase II of the Central Engine Study were very encouraging for systems comprised of a 50-MW_e steam Rankine turbine, a thermochemical transport system, and near-term technology dishes. The study, in fact, indicated that the optimum size of such a plant might be larger than the 50-MW_e size studied. Documentation will be completed this fiscal year.

The Central Engine Study final report will be published in FY88, and the effects of certain approximations in the modeling of the sensible transport system during the Central Engine Study will be resolved.

The major effort for FY88 will be a study of dish-electric systems with Stirling engines. Both kinematic and free-piston Stirling engines systems will be considered. This study will consist of model development, a technical feasibility study, conceptual designs, performance and economics, technical uncertainty identification, and a program plan to guide R&D of dish-electric systems. Other relevant systems such as the Vanguard project and the two Small Community Experiments will also be analyzed. Available information on each of the systems will be gathered, condensed, and standardized for use. Thus, alternate dish-electric systems will have one common consistent analysis which will lead to insights in the trade-offs of each.

A systems analysis activity will support Sandia's internally funded work on solar destruction of hazardous wastes. The FY88 effort will focus on a market assessment, which will identify, by industry type, the major generators of hazardous wastes; the types and quantities of hazardous wastes produced; and the current disposal costs. In addition, competing disposal technologies will be evaluated in order to understand and enhance the advantages of the solar destruction option. This market assessment will lead to a conceptual design of the overall system in FY89. Based on promising destruction processes identified during the internally funded design and demonstration task, a system conceptual design will be developed that applies the process to a particular hazardous waste. The design will include determination of the solar input required and the preferred system location (on-site versus remote) and operating mode.

Resource Requirements, Task 10.1

Costs (k$)	FY88	FY89
In-house	352	680
Contracts	20	100
Total costs (k$)	372	780
Manpower (man-yr)	2.2	4.0

Subtask 10.2, Distributed Receiver Test Facility (Operation and Maintenance)

The Distributed Receiver Test Facility supports testing of point and line focus components and systems. Permanently installed capability includes two 11-m Test Bed Concentrators, an Engine Test Facility, a rotating platform for testing of line focus components, and four line-focus systems installed under the MISR program.

The DRTF will be maintained and operated as required to support testing under the various tasks, including testing of engines, receivers, the SCSE verification modules, the concentrators from the Innovative Concentrator and stretched membrane concentrator programs, and the Thermochemical Closed Loop Operations Experiment. Test requirements and resources to support specific tests are included under the relevant task descriptions. Resources for Task 10.2 provide for upgrade, as well as operation and maintenance of the active test facility.

A video-based fluxmapper was developed for the DRTF in FY87. During early FY88, the fluxmapper will be used to characterize Test Bed Concentrator #1. The results will be compared to CIRCE predictions to permit validation of this optical computer model. The fluxmapper will then be available for support of concentrator, receiver, and reimbursable test programs. Minor facility upgrades will be made to support receiver and STM experiments.

The facility will be used also to conduct reimbursable tests for other programs and agencies. Reimbursable tests are scheduled on a noninterference basis with planned solar test activities.

Resource Requirements, Task 10.2

Costs (k$)	FY88	FY89
In-house	176	340
Contracts	200	460
Total costs (k$)	376	800
Manpower (man-yr)	1.1	2.0

Subtask 10.3, Shenandoah Solar Total Energy Project

The Solar Total Energy Project (STEP) is the world's largest solar plant using the cogeneration concept of energy production for an industrial application. The project produces electricity, process steam, and chilled water air conditioning for a knitwear factory operated by Bleyle of America. Solar energy generates a large part of the electricity and displaces part of the fossil fuels normally required to operate the factory.

The STEP program, initially funded by the DOE and operated by the Georgia Power Company under the technical direction of SNLA, is currently operated and funded by GPC at a cost of approximately $1M per year. SNLA continues to provide technical assistance to the project.

The STEP plant has been extensively modified and upgraded in FY87 through the incorporation of a gas-fired steam superheater to improve the electrical output, a high-pressure surge tank to stop Syltherm heat transfer fluid losses, a larger area steam boiler tube bundle to improve heat transfer and provide safety, and a new solar field control system that provides better collector control. Also, FEK aluminum film has been replaced with ECP300 silver film on one row of solar collectors (out of 12 rows) so that comparative field performance data may be obtained.

Sandia has contracted with Georgia Power to conduct systems and component tests to evaluate the improvement in performance brought by the upgrade modification, to determine the benefits of silvered versus aluminum film for use on concentrators, and to determine the effect of cleaning aluminized film. Sandia has also contracted with California Polytechnic Institute to measure the thermal losses of receivers and determine the relative magnitudes of the various heat loss mechanisms (conductive, convective, and radiative).

Plans for the FY88 include evaluation of data obtained from the current testing program and the testing systems and components to determine: 1) how well the modified and upgraded system performs in an intensive power production mode, and does actual performance meet predictions and validate system analytical models, 2) how to best use the gas-fired superheater to optimize its effectiveness and lower the cost of energy production, 3) the relationship between supplemental energy added to the system by the fossil-fueled heater and that added by the superheater, 4) how to vary the three energy outputs (electrical, process steam, and chilled water) as a function of solar insolation, and 5) how to minimize the cost of energy produced through operating and control strategies. Evaluation of the data from the current testing program is projected to be complete by March 1988. Additional testing will be required. It will be performed during CY88 and the evaluation of all data completed by June 1989.

Resource Requirements, Task 10.3

Costs (k$)	FY88	FY89
In-house	32	34
Contracts	40	75
Total costs (k$)	72	109
Manpower (man-yr)	0.2	0.2

R&D TASK 11, SYSTEMS EXPERIMENTS

Systems experiments are tests of solar energy equipment assembled into full functional systems. They are performed in real or simulated environments and are extensively instrumented to measure system performance in detail. System experiments constitute the final step in solar energy development projects.

Status and Planned Activities

Subtask 11.1, Small Community Solar Experiments (SCSE)

Two experiments are planned to evaluate solar electric plants in a small-community-utility environment. One will be located at Osage City, Kansas (SCSE#1), and the other on Molokai Island, Hawaii (SCSE#2). Barber-Nichols was selected as the prime contractor for the site at Osage City. Power Kinetics Inc. was selected as the contractor for the Molokai experiment.

The SCSE projects are structured in four phases:

1. Solar Plant Design
2. Module Verification
3. Solar Plant Installation
4. Solar Plant Operation and Maintenance

Sandia's responsibility to these DOE/AL contracted projects is to provide technical and management support to DOE/AL and to provide all services required at the DRTF to evaluate the module verification units. Close day-to-day contact is maintained with the responsible contractors.

Module verification testing at the DRTF for SCSE#1 was to have been completed in FY87. Serious problems with the PKI concentrator and the Barber-Nichols ORC engine has caused the schedule to slip. The PKI concentrator was plagued with structural problems and the decision was made to not continue with the PKI concentrator but to use the LaJet Innovative Concentrator. Module Verification Tests of the Barber-Nichols, LaJet SCSE #1 module will be completed at the DRTF in FY88 and the equipment for the SCSE#1 at Osage City will be fabricated and installation will begin. In FY89 the installation of SCSE#1 will be completed, checkout and start-up will be conducted, and operation of the plant will commence.

Sandia devoted far more manpower to management support and DRTF support than was budgeted in FY87. The same will be true in FY88 if problems persist. Already delays in the LaJet IC concentrator testing are impacting the program.

An automated data system similar to the On-Site Data Acquisition System used at several DOE PV experimental sites is being designed by SNLA for both SCSEs and special software for these dish-electric applications will be written. The data system will be installed at the DRTF and its operation checked out during the module verification testing. The data system will provide weather and operational data for each experiment. After installing the data systems at Osage City and Molokai, the site data will be sent via telephone to Albuquerque for reduction and distribution.

The SCSE#2 (Molokai, Hawaii) solar plant design has been completed. The hardware for the verification test module has also been manufactured and the module erected at SNLA's DRTF. Due to design problems, the module verification test has slipped but is currently scheduled to begin at the DRTF in March 1988. The Molokai site construction depends on the outcome of the verification testing but is tentatively scheduled to begin June 1988 and be completed by December 1988. One year of on-plant site operation will be conducted during 1989. The above comments on budgeting Sandia support also apply here.

Resource Requirements, Task 11

Costs (k$)	FY88	FY89
In-house	224	85
Contracts	89	30
Total costs (k$)	313	115
Manpower (man-yr)	1.4	0.5

CHAPTER 4. RESOURCES AND IMPLEMENTATION

This chapter provides summary information in several formats for the FY88 and FY89 plans for SNLA's Solar Thermal Projects. This information includes:

Major Milestone Charts
Resource Requirements Summary Table
Management Plan
Procurement Plan
Project Organization and Key Personnel

Major Milestones for FY88 and FY89

The most important milestones have been assembled onto the Major Milestone Chart in Figure 4.1. The selection of these milestones reflects both the focus of the projects on the most critical R&D needs for distributed receiver technology and the importance of achieving these milestones to realize the Solar Thermal Technology Program goals.

Resource Requirements Summary

The manpower and budgetary resources required for the plans described in Chapter 3 are summarized in Table 4.1. The resource allocations follow the emphasis within the project on concentrator and engine R&D needs while still maintaining a reasonable balance among all aspects of distributed receiver technology development.

Summary of Deliverables

The following is a list of deliverables for FY88. In the case of reports, the dates listed are estimated publication dates and the deliverable includes the author(s) and title. The distribution of all reports will be UC-236 plus the Sandia Distributed Receiver Standard Distribution.

Date	Deliverable
Mar 88	LaJet Energy Co., Contractor's Report. "Final Report on Stretched Membrane Conceptual Design"
Mar 88	Solar Kinetics, Inc., Contractor's Report. "Final Report on Stretched Membrane Conceptual Design"
Apr 88	Argonne National Laboratory, Contractor's Report. "Stirling Reliability and Failure Modes and Effects Analysis"
Apr 88	Richardson, J. T. "Catalyst Development in Support of Thermochemical Energy Transport"
May 88	MTI, Contractor's Report. "Final Report on Free-Piston Stirling Engine Design"
May 88	STC, Contractor's Report. "Final Report on Free-Piston Stirling Engine Design"

Jun 88	Lukens, L. L., J. P. Abbin, C. E. Andraka, and J. B. Moreno. "A Liquid Metal Thermal Electric Converter"
Jun 88	Muir, J. F. "Performance/Economic Analysis of Thermochemical Versus Sensible Energy Transport for Distributed Receiver Solar Thermal Systems"
Aug 88	Fish, J. D. and Hawn, D. C. "Closed-Loop Experiments on CO2/CH4 Reforming and CO/H2 Methanation in the CLEA Laboratory"
Sep 88	Diggs, J. M. "Results of Phase II of Central Engine Study"
Sep 88	Muir, J. F. "The Growth and Demise of CLOE: A Closed Loop Operations Experiment on Thermochemical Energy Transport for Solar Thermal Applications"
Feb 89	Annual Solar Thermal Technology Conference

Management Plan

Management encompasses project planning, coordination, control, reporting, and programmatic support and technology transfer.

Project Planning -- The primary project planning activities consist of (1) supporting the preparation and regular revision of the Five-Year Research and Development Plan, and (2) preparation of this two-year Sandia (SNLA) Development Plan on an annual basis.

Project Reporting -- Project reporting is conducted at several levels. Within the federal Solar Thermal Technology Program weekly and quarterly reports are prepared, and oral reviews are conducted on a quarterly basis. The quarterly reports coincide with and serve as documentary support for the oral reviews. In addition, material on distributed receiver technology development is prepared for the Solar Thermal Technology Annual Evaluation Report and the Solar Thermal Program Summary Document.

Solar Thermal Program Documentation Support -- The DOE Office of Solar Heat Technologies is engaged in preparing summary technology transfer documentation of the major results of completed R&D efforts across the solar heat and solar thermal technologies. In FY87 SNLA accepted the responsibility for managing the completion of two Solar Thermal volumes in the Documentation Project. A contract with the University of Houston will be placed in the first quarter of FY88 for editorial and technical writing services. The project will continue through FY88 (on prior year funding) and will be completed in FY89.

Technology Transfer -- Formal technology transfer activities include publishing and widely distributing technical reports on all aspects of the project, participating in national and international technical conferences, and organizing and hosting the Annual Solar Thermal Technology Conference. Design assistance is furnished to private sector developers and prospective users. Some of the most important technology transfer activities include frequent technology exchanges or briefings with a wide variety of visitors from various industries, federal agencies, and universities. These take place over the telephone as well as face to face.

Table 4.1

RESOURCE REQUIREMENTS SUMMARY

DISTRIBUTED RECEIVER PROJECT -- FY88/89

TASK	FY 1988 In-house MY	FY 1988 In-house $k*	FY 1988 $Cntrct	FY 1988 $Totl	FY 1989 In-house MY	FY 1989 In-house $k*	FY 1989 $Cntrct	FY 1989 $Totl
COLLECTION TECHNOLOGY								
1.0 OPTICAL MATERIALS	1.3	208	50	258	2.3	391	260	651
2.0 CONCENTRATORS	2.8	457	975	1432	3.5	595	1500	2095
3.0 RECEIVERS	5.1	758	238	996	3.8	646	900	1546
ENERGY CONVERSION TECHNOLOGY								
4.0 HEAT ENGINES	3.5	589	722	1311	6.1	1037	1355	2392
6.0 TRANSPORT AND STORAGE	1.2	170	80	250	4.4	748	285	1033
8.0 BALANCE OF PLANT	0	0	0	0	0.9	153	50	203
SYSTEMS & APPLICATIONS TECHNOLOGY								
10.0 DISTR RECEIVER SYSTEMS	3.5	560	260	820	6.2	1054	635	1689
11.0 SYSTEM EXPERIMENTS	1.4	224	89	313	1.7	289	170	459
TOTALS	18.8	2966	2414	5380	28.9	4913	5155	10068

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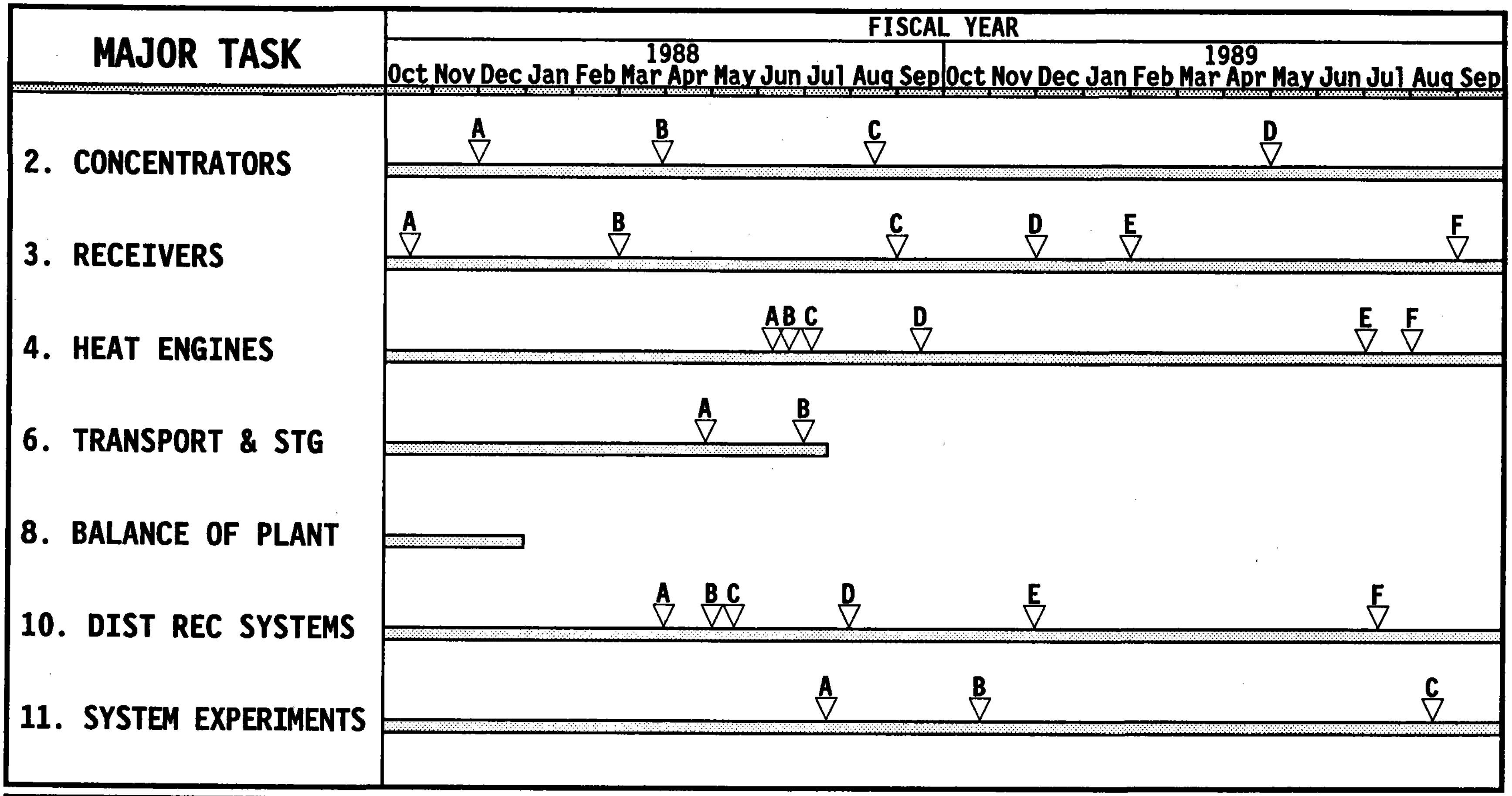
* In-house costs include all SNLA non-contracted costs. These include not only labor and overhead, but also travel, computer charges, drafting, test, shop, tech art, and stockroom withdrawals.

DISTRIBUTED RECEIVER DEVELOPMENT PROJECT - FY88/89



2. CONCENTRATORS
   - A=COMPL DDR STR MEMB DESIGNS
   - B=PLACE STR MEMB PHII CONTRACT
   - C=COMPL DRTF TESTS OF LaJET IC
   - D=BEGIN TESTS INTERIM STR MEMB AT DRTF

3. RECEIVERS
   - A=INITIATE DCAR REC DEV FOR CAESAR
   - B=COMPLETE TEST BED REC VALIDATION STDY
   - C=DELIVER STM RECEIVER TO DRTF
   - D=INITIATE TESTING OF REFLUX REC AT DRTF
   - E=SHIP CAESAR CATALYST INSERT TO GERMANY
   - F=DECISION PT-REFLUX BOILER OR HEAT PIPE

4. HEAT ENGINES
   - A=COMPLETE CONTROL SYSTEM FOR KSE
   - B=DELIVER STM KSE 4-120 TO DRTF
   - C=COMPLETE LMTEC SUMMARY REPORT
   - D=PLACE FPSE PHII CONTRACT
   - E=BEGIN ON-SUN TESTING OF KSE
   - F=COMPL FPSE DETAIL DESIGN

6. TRANSPORT & STG
   - A=COMPL HIGH TEMP CLEA LAB TESTS
   - B=COMPLETE CLOE DRAFT SUMMARY REPORT

10. DIST REC SYSTEMS
   - A=COMPLETE SHEN STEP SUMMARY REPORT
   - B=COMPLETE DISH-ELECTRIC PRELIM STUDY
   - C=KSE/FPSE CONCEPTL DES FORTRAN MDL OPNL
   - D=DISH-ELECT STY SOLAR-ONLY PREDICTNS CMPLT
   - E=DISH-ELECT STY HYBRID PREDICTNS CMPLT
   - F=PRELIM DISH-ELECTRIC O&M STUDY CMPLT

11. SYSTEM EXPERIMENTS
   - A=COMPL DRTF TESTS OF SCSE2 MODULE
   - B=COMPL DRTF TESTS OF SCSE1 MODULE
   - C=COMPL SCSE2 C/O & STARTUP (DOE/AL)

DR88A0P 3-31-88

FIGURE 4.1

In FY88 a more active presence will be established and maintained in CORECT so that developers of solar thermal technology will have access to the marketing opportunities being coordinated by this agency.

Interagency Coordination -- Coordination of R&D efforts between SNLA and NASA on solar thermal electric technology is rapidly increasing because of NASA's growing interest in space solar dynamic technology in the range of tens to hundreds of kilowatts. In FY87 NASA interest in SNLA's solar technology capabilities resulted in two small reimbursable contracts, which have the potential for expansion to include Solar Thermal's private firms. This cooperative, mutually beneficial liaison will be maintained. Opportunities for increased participation in solar space power development by firms in the solar thermal "family" will be sought.

Procurement Plan

Procurement Strategy -- Procurements for the distributed receiver development program are initiated by Sandia, upon approval of this Distributed Receiver Development Plan by DOE/HQ. The procurement summary listed in Table 4.2 provides a list of those new procurements that are anticipated in FY87. Table 4.3 lists the major active contracts placed on FY86 or prior year Budget Authority.

Procurement Policy and Practices -- Sandia's procurement rules are similar to the DOE regulations; however, they are not identical. In the substantive cases where they are not, but which have impact on the program, measures are taken to assure that programmatic requirements are met. An example of this is the policy of advertising competitive procurements in Commerce Business Daily and any other appropriate publication. (This is not generally done on Sandia procurements.) With few exceptions, R&D procurements in this program are competitive, with the sole source option being used only in instances where it is very clear that a certain contractor is the only one who can fulfill the function.

Small and Minority Business Policy -- It is both DOE policy and Sandia policy to maximize the use of small and minority businesses in carrying out the programs under their management.

Project Organization and Key Personnel

Sandia uses a matrix organizational structure which incorporates a broad range of supporting materials, engineering, computational, fabrication, and testing capabilities which are directly available for the varied needs of the project organizations. The Solar Thermal Projects at SNLA are conducted within the Solar Energy Department under the Director of Advanced Energy Technology. Specific responsibility for the distributed receiver projects is assigned to two divisions. This project structure, along with the task assignments, is displayed in Figure 4.2. This structure does not display the relationship and roles of the various functional supporting organizations. This support is arranged and provided at the division and staff member working level, which permits considerable efficiency and flexibility. About 40% of internal labor is provided to the Solar Thermal Projects from functional organizations.

TABLE 4.2
SANDIA NATIONAL LABORATORIES
DISTRIBUTED RECEIVER PROJECT

PROCUREMENT SUMMARY FOR FY88
MAJOR ANTICIPATED CONTRACTS

TITLE	TASK	VALUE	PROJ ENGR	START
IPH REPORT EDITOR	--	20	J. LEONARD	JAN 88
SOL-GEL MIRROR PROCESSING	1.1	40	E. RUSH	JUL 88
STRETCHED MEMBRANE CONCENTRATOR	2.2	900	T. MANCINI	APR 88
STRUCTURAL ANALYSIS SUPPORT	2.2	50	T. MANCINI	MAR 88
HEAT LOSS STUDIES	3.1	20	A. HECKES	JAN 88
RECEIVER CODE DEVELOPMENT	3.1	30	R. DIVER	MAR 88
REFLUX RECEIVER DEVELOPMENT	3.2	75	R. DIVER	JAN 88
CAESAR CATALYST DEVELOPMENT	3.2	75	J. FISH	JAN 88
CAESAR TEST/SUPPORT EQUIPMENT	3.2	50	J. FISH	JUN 88
GAS COMBUSTOR	4.2	30	K. LINKER	FEB 88
FREE PISTON STIRLING ENGINE PHII	4.2	600	K. LINKER	JUN 88
ETF FACILITY CONSTR FOR KSE	4.2	40	K. LINKER	NOV 87
DISH-ELECTRIC CODE DEVELOPMENT	10.1	50	J. DIGGS	JAN 88
DRTF OPERATING CONTRACTS	10.2	300	C. CAMERON	JUL 88
SHENANDOAH TESTS	10.3	40	A. HECKES	MAY 88
CROSBYTON SITE RESTORATION	11.0	40	M. QUINTANA	MAY 88

TABLE 4.3

SANDIA NATIONAL LABORATORIES
DISTRIBUTED RECEIVER PROJECT
PROCUREMENT SUMMARY

MAJOR ACTIVE CONTRACTS PLACED ON
FY87 AND PRIOR YEAR BUDGET AUTHORITY

CONTRACTOR	TASK	TITLE	VALUE	TYPE	PROJ ENGR	PO/PR	COMPLT	BAL
UNIVERSITY OF HOUSTON	---	DOCUMENTATION PROJ EDITOR	144	UNIV	J. LEONARD	06-8076	DEC 89	132
SOLAR KINETICS INC	2.2	STRETCHED MEMBRANE CONCPT	551	SMALL	T. MANCINI	53-9663A	JUN 88	0
LAJET ENERGY CO	2.2	STRETCHED MEMBRANE CONCPT	496	SMALL	T. MANCINI	53-9663B	JUN 88	138
TIW FABR & MACHINE	2.2	SOLAR COLL PEDESTAL FAB	57	SMALL	T. MANCINI	57-4436	JUN 88	57
UNIVERSITY OF NEW MEXICO	2.2	SOL-GEL PORE ANALYSES	31	UNIV	J. BRINKER	02-2456	MAR 88	0
C. TWAN, CONSULTANT	2.2	ENGINEERING SERVICES	18	SMALL	T. MANCINI	33-4255	MAR 89	13
TECH REPS	3.1	TECH SUPPORT SERVICES	100	SMALL	R. DIVER	01-2370	DEC 88	37
LBNL	3.1	STUDY DIR CATLYST ABS REC	80	GOVT	R. DIVER	02-7450	MAR 88	1
CAL POLYTECHNIC KELLOGG	3.1	RECEIVER HEAT LOSS TESTS	55	UNIV	A. HECKES	02-5759	OCT 87	0
CLARKSON UNIVERSITY	3.1	TEMPERATURE MAPPING TOOL	39	UNIV	R. DIVER	32-3242	SEP 87	0
KIRK-MAYER	3.2	TECHNICIAN SUPPORT	110	LARGE	R. DIVER	01-9646	MAR 89	41
NASA LeRC	4.2	FREE PIS STRLNG ENG DESGN	700	GOVT	K. LINKER	DOE/ALO	SEP 88	200
STIRLING THERMAL MOTORS	4.2	COML KIN STIRLING ENGINE	300	SMALL	K. LINKER	53-8452	DEC 88	300
STIRLING THERMAL MOTORS	4.2	DES & FAB SOLAR REC (KSE)	124	SMALL	K. LINKER	33-3036	MAY 88	45
SCHENCK PEGASUS CORP	4.2	DYNAMOMETER	38	SMALL	K. LINKER	06-1602	APR 88	8
TOM FELDMAN, CONSULTANT	4.2	HEAT PIPE CONSULTATION	15	SMALL	K. LINKER	06-5628	SEP 88	0
UNIVERSITY OF PENNSYLVANIA	4.3	HG-BETA-ALUMINA STUDY I	200	UNIV	W. HAMMETTER	64-9240	DEC 87	0
UNIVERSITY OF WISCONSIN	4.3	HG-BETA-ALUMINA STUDY II	99	UNIV	W. HAMMETTER	95-2054	DEC 87	0
CERAMATEC	4.3	BETA ALUMINA TUBES	18	SMALL	L. LUKENS	57-0505	JUN 87	0
UNIVERSITY OF HOUSTON	6.2	CATALYSIS, REACTOR RESRCH	75	UNIV	J. FISH	53-7216	NOV 87	0
BLACK & VEATCH	6.3	CLOE INSTALLATION DESIGN	75	LARGE	C. CAMERON	01-2345	DEC 87	10
TECHNADYNE	10.1	COMP/PROGRAMMING SUPPORT	275	SMALL	M. FEWELL	14-1523	DEC 87	0
EG&G	10.2	SOLAR TEST SUPPORT	590	LARGE	C. CAMERON	52-5653	JUL 88	78
EWING TECH DESIGN INC	10.2	DRTF SCSE SUPPORT	257	LARGE	J. OTTS	48-0942	SEP 88	57
WG ASSOCIATES	10.2	TBC/ACUREX ANALYSIS	100	SMALL	C. CAMERON	33-1510	JUN 88	22
COLORADO ST UNIV	10.2	ANALYSIS OF LEC WIND DATA	12	UNIV	J. STRACHAN	02-7834	SEP 87	0
GEORGIA POWER CO.	10.3	STEP UPGRADE TESTS	74	LARGE	A. HECKES	06-3049	JAN 88	0
GEORGIA POWER CO	10.3	SUMMARY REPORT	25	LARGE	A. HECKES	53-8034	APR 88	0
U OF HAWAII-MANOA	11.1	SMALL COMM EXPERIMENT	74	UNIV	J. OTTS	56-6959	FEB 88	0

ENERGY PROGRAMS
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Supervisor, J. A. Leonard

Optical Materials, Task 1
Concentrators, Task 2
Receivers, Task 3
Heat Engines, Task 4
Transport and Storage, Task 6
Balance of Plant, Task 8
Distributed Receiver Systems, Task 10
System Experiments, Task 11

Figure 4.2. Organizational Structure for SNLA's Solar Thermal Projects