Distributed Receiver Development Plan 1986-1987

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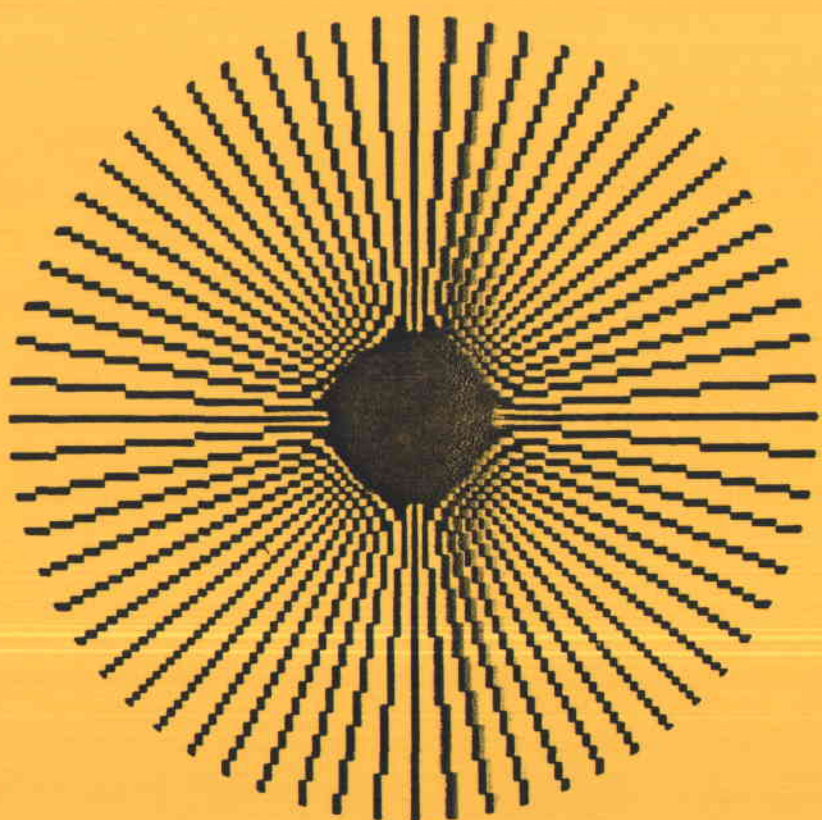

Department of Energy
Solar Thermal Technology Program

DISTRIBUTED RECEIVER DEVELOPMENT PLAN

1986–1987

Solar Energy Department
Sandia National Laboratories
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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 three major field centers, SNLA, SNLL, and SERI, and by two DOE operations offices, AL and SAN. These five organizations each prepare and publish their individual planning documents describing detailed plans for the succeeding two 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 Projects for FY86 and FY87. During this period SNLA will gradually assume responsibility for the Central Receiver R&D currently under the direction of SNLL. This document, however, will discuss only the Distributed Receiver Project. The development plan for the Central Receiver Program for FY86 and FY87 is being prepared by SNLL.

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 FY86 and FY87 Solar Thermal Projects Plan in several formats: a compilation of major milestones, a summary of resource requirements, a discussion of capital equipment requirements, a description of the management plan, a listing of proposed contract procurements, a table of deliverables from SNLA, and the organizational structure and key personnel within SNLA.

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[1] "National Solar Thermal Technology Program: Five-Year Research and Development Plan, 1985-1989," available from the Division of Solar Thermal Technology, U.S. Department of Energy; 1985.

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 SNLL, SNLA, and SERI. SNLL has been responsible for central receiver technology. However, this responsibility is being transferred to SNLA. 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 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.

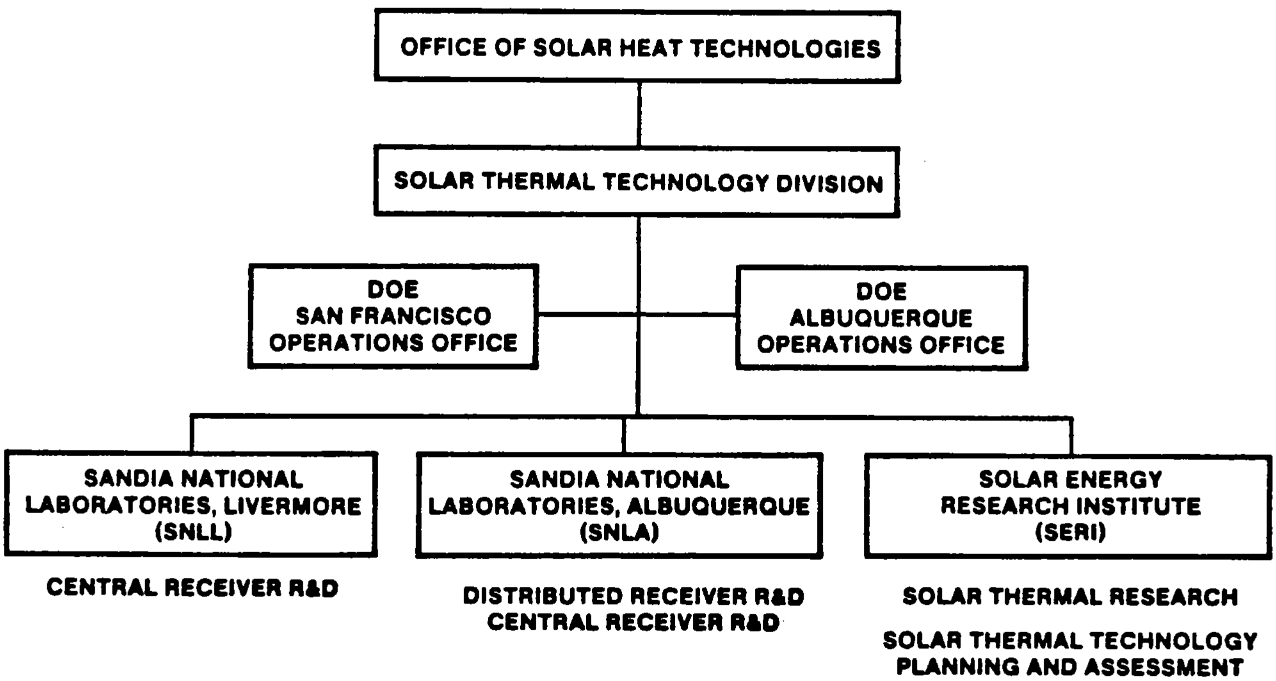


Figure 2.1. Solar Thermal Technology Organizational Structure and Responsibilities

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, troughs, and bowls (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 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 from a system perspective
10. Distributed receiver systems	Activities related to the analysis and development of distributed receiver applications on a system level

Table 2.1. (Continued)

R&D Task	Definition
11. System experiments	Activities related to the design construction, startup, 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 have been judged on the basis of systems analyses, cost projections, and data from operating systems.

Table 2.2. Solar Thermal Technology Long-Term Targets

	System Product	
Characteristic	Electricity	Heat
System annual efficiency	22%-28%	56%-68%
System capital cost[a]	$1300-1600/kWe	$400-490/kWt
System capacity factor	0.25-0.5	0.25-0.3
System energy cost[b]	$.05/kWhe	$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.

The magnitude of the improvements proposed by the DOE Five-Year Plan can be illustrated by comparing the cost/performance ratios for current dish capabilities against those forecast by the long-term targets. The cost/performance ratio is computed by dividing the solar energy system capital cost by the annual energy production capability of the system; the units are $/(kWh/yr). These ratios for both electric and thermal applications are shown in Figure 2.2.

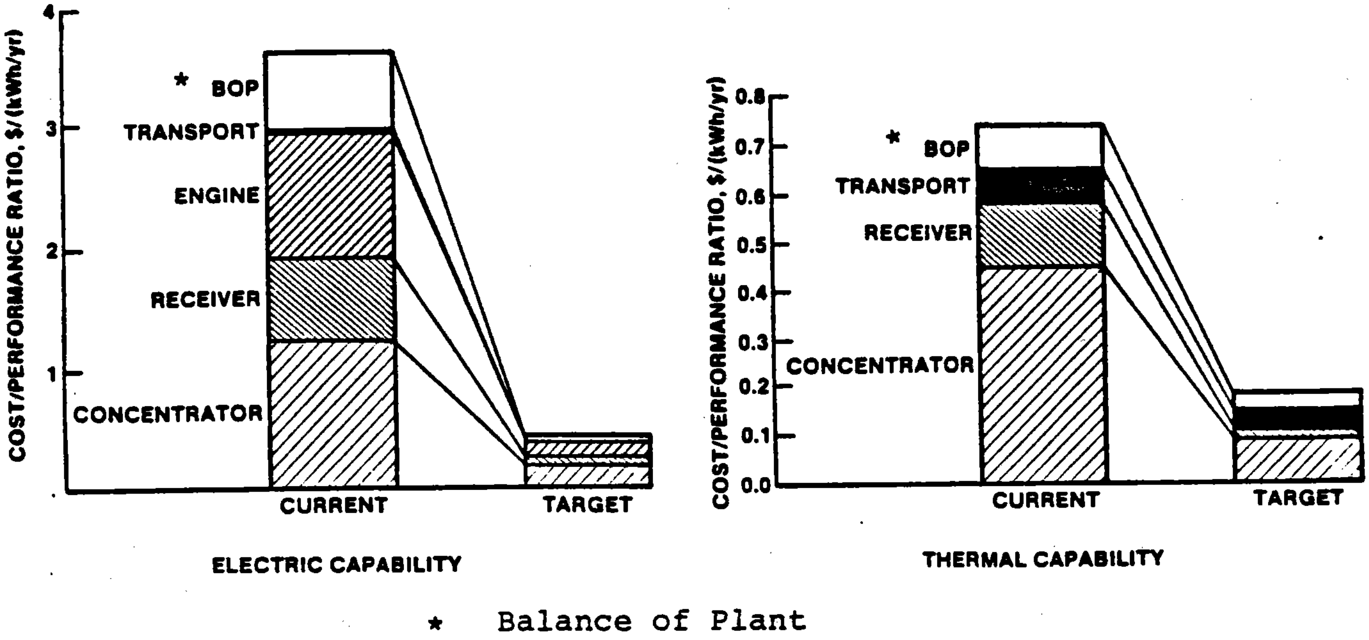


Figure 2.2. Comparison of Current and Target Cost/Performance Ratios for Dish Electric and Thermal Applications

CHAPTER 3. DISTRIBUTED RECEIVER DEVELOPMENT PROJECT PLAN, FY86 AND FY87

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 FY86 and FY87, SNLA proposes to participate in seven of the eleven major tasks described in the DOE 5-Year Plan. The remainder of this chapter contains the detailed R&D plans for FY86 and FY87 for each task and subtask in the SNLA Distributed Receiver Development Project.

Table 3.1. SNLA Distributed Receiver Project Subtask Structure

Task 2.	CONCENTRATORS	
	Subtask 2.1	Line-Focus Concentrators
	Subtask 2.2	Point-Focus Concentrators
	Subtask 2.3	FMDF Management
Task 3.	RECEIVERS	
	Subtask 3.1	Receiver Analysis
	Subtask 3.2	Receiver Development
Task 4.	HEAT ENGINES	
	Subtask 4.1	Heat Engine Analysis
	Subtask 4.2	Gas and Vapor Power Cycles
	Subtask 4.3	Thermal Electric Converters
Task 6.	TRANSPORT AND STORAGE	
	Subtask 6.1	Code Development
	Subtask 6.2	SO_3 Dissociation
	Subtask 6.3	CO_2/CH_4 Reforming
	Subtask 6.4	Field-Scale Experiment
Task 8.	BALANCE OF PLANT	
Task 10.	DISTRIBUTED RECEIVER SYSTEMS	
	Subtask 10.1	Systems Engineering and Analysis
	Subtask 10.2	Distributed Receiver Test Facility
	Subtask 10.3	Evaluation of Field Experiment Projects
Task 11.	SYSTEM EXPERIMENTS	
	Subtask 11.1	Small Community Solar Experiments

R&D TASK 2, CONCENTRATORS

The objective of this task is to develop high-performance, low-cost concentrators for thermal processes and electrical power generation.

At SNLA, the concentrator task is divided into two subtasks based on the geometric configuration used to concentrate the solar energy, i.e., line- and point-focus systems.

A third type of concentrator, the heliostat, has been a part of SNLL's Central Receiver activities that are in the process of being transferred to a newly formed Central Receiver Division at SNLA.

Status and Planned Activities

Subtask 2.1, Line-Focus Concentrators -- Current efforts in line-focus concentrator development center on six component development contracts placed in March of 1985 and an internal evaluation of the status of line-focus concentrator costs. The projects were selected on the basis of their importance in improving the performance, operation, or maintenance of generic line-focus concentrator systems. Two of these contracts are to improve sun-tracking control systems; two are aimed at developing better receivers by improving the glass-receiver tube seals and by developing an evacuated receiver; one is for improving glass/steel laminate as an optical surface; and the last is for the development of an inexpensive embedded post for field mounting collectors. These contracts will be completed during the first and second quarters of FY86 and, at that time, the components will be delivered to the DRTF for evaluation.

In FY86 SNLA will begin an advanced line-focus development project. Using performance data and operating experience from the MISR and Component Development projects, SNLA will undertake a study of line-focus collector subsystems that will target areas of improved performance, reduced wieght, and reduced manufacturing costs. The effort in FY86 will be mostly in-house with the study being completed in August 1986. A competitive RFP for design of this line-focus concept will be released in the 1st quarter of FY87

Subtask 2.2, Point-Focus Concentrators -- The present status of point-focus concentrator development is connected with the DOE Innovative Concentrator Project. Three companies, Acurex, Entech, Inc., and LaJet Energy Company, are presently under contract through the Albuquerque Operations Office to design point-focus concentrators. Sandia supports the DOE/AL office by providing technical management for the Innovative Concentrator Project. In addition to the three Innovative Concentrator contracts, Sandia has a contract with Solar Kinetics, Inc. for the design of a point-focus concentrator using a three-dimensional, roll forming technique. Each of the Innovative Concentrator Project participants is designing a point-focus concentrator to meet specific performance and survivability criteria. The concentrator system includes the optical elements, the supports and foundations, tracking drives and controls, and the mount for the power conversion assembly. In addition, a design must be modular and mass producible; it must be economic to manufacture, operate and maintain; and it must have low life-cycle costs consistent with the interim goals in the Five-Year Plan and have a 10- to 20-year life.

The Innovative Concentrator project is structured in two phases. In Phase I, the contractors develop a concentrator design and demonstrate the fabricability of the optical elements. Phase II will begin in FY86, where a full-scale prototype concentrator is built and tested at the Distributed Receiver Test Facility in Albuquerque. A detailed design review of all four concentrator designs will be held during the first and second quarters of FY86. The DOE will proceed to Phase II on FY86 funds with those contractors whose designs show significant improvement in performance/cost over current designs and offer potential for achieving the five year goal of the 1985 Solar Thermal Five-Year Plan.

Sandia is developing an in-house concentrator. This effort began in FY85 with the initiation of a computer code development to model a concentrator-receiver. It is intended that this code will grow to incorporate economics, thermo-chemical receivers, and heat engines. A number of concentrator concepts are being considered and compared with the baseline case, a stretched-membrane concentrator. Concepts alluded to above include stretched membrane single facet designs which would be an adaptation of the current stretched membrane heliostats, multiple large facet stretched membrane designs, adaptations of the German/Saudi preshaped deformed skin, stretched membrane skin pulled over a concave lattice "sieve" structure, stretched membrane skin on a radial rib "umbrella" structure, the "pararing" dish in which concentric stretch-formed rings are mounted on a flat structure for wind avoidance, and the field-poured mold which was conceived in FY84 in the ultra-low-weight zero-wind study. All concepts will be based on metallic and polymeric films when applicable. Concepts using metallic membranes will feature the sol-gel, silvered sheet steel development. The most promising design will be selected in February 1986 for detailed evaluation. Industry contracts for optical element concept generation and preliminary evaluation will be placed in the third quarter of FY86. These contracts are the precursors to a full-scale RFQ to be issued during the first quarter of FY87 for the detailed design and construction of the optical elements. In this way, SNLA and industry will work together toward the development of the next generation concentrator. A Preliminary Design Review which will include performance predictions, structural design and initial cost estimates will be conducted in August 1986.

SERI has primary responsibility for optical materials development and testing, but Sandia also does some work in this area in support of the concentrator design activity and where unique expertise exists in-house. An area of special interest is the development of silver-stainless steel, structural mirrors. Sandia has established that good structural mirrors can be made and protected with a sol-gel glass coating. Mirrors made in this way demonstrate a specular reflectivity of 91% within a 6 mr cone angle. The sol-gel coated silvered-steel mirror is structural and can substantially reduce the weight and, therefore, the cost of the concentrator. Process development activities will be completed in February 1986. Confidence in the viability of the final process and the importance of this material to light-wieght concentrator development warrants an early start on scale-up activities. The process development labs at SNLA will develop silvered and sol-gel coated stainless steel sheets in sizes of about 0.5 m. These will be subjected to endurance testing beginning in May 1986. The next step of scale-up will include technology transfer to one or more private firms and the production of material which could be installed on facets of the LEC 460 at the DRTF by the 1st quarter of FY87.

Subtask 2.3, Fixed-Mirror Distributed-Focus (FMDF) System -- The Fixed Mirror Distributed Focus (FMDF) concept is being pursued by Texas Tech University under a prime contract from DOE/AL. The contract is for a three-phase R&D program that is scheduled for completion in August 1986. Work has progressed to Phase III, Operational Testing. Current activities include (1) analysis of mirror panel layout, aerodynamic flow and loading, and environmental suitability; (2) testing of super mirror panels, of fluid control and instrumentation, and of a large solar boiler for an alternate application; (3) daily operation of the analog design verification system at Crosbyton, TX, to obtain long-term performance data; and (4) reassessment of alternate uses for FMDF. The contract has been funded as a multiyear effort using commitment authority from a prior year. As with other prime DOE/AL contracts in the Distributed Receiver area, SNLA provides technical support to the AL project office.

Resource Requirements, Task 2

Costs (k$)	FY86	FY87
In-house	600	675
Contracts	1365*	1285**
Total costs (k$)	1965	1960
Manpower (man-yr)	4.7	5.0

*Includes $865K of DOE/AL funding for the initiation of Phase II of the Innovative Concentrator Project.
**Includes $400K of DOE/AL funding for the completion of Phase II of the Innovative Concentrator Project.

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% efficiencies that can be manufactured for $30/m^2 of concentrator aperture area (see Five-Year Plan). The objective of this task for FY86 and FY87 is to continue to develop the analytical and experimental tools and techniques necessary to design efficient receivers, to evaluate receiver performance, and to make cost-effective trade-offs.

Energy losses from receivers have typically been higher than expected. It has become evident that improved receiver performance can be a cost effective way of improving system performance. More effort has, therefore, been directed at identifying the various losses.

Our plans for the next 2 years are to

- Continue to develop analytical (computer modeling) tools for receiver design analysis,
- Characterize the performance of existing receivers,
- Develop an understanding of receiver performance via modeling and receiver experimentation, and
- Develop receivers for thermochemical transport and 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 CAV/CVT codes that were made operational in 1985 will be used in the short term and more sophisticated programs will be pursued in the fW+ The models will continue to integrate the concentrator with the receiver and thermal loads. Codes will be validated with existing receiver data, data taken from receivers under development, and with data taken from the Test Bed Receiver (TBR). The TBR is a versatile high-temperature calorimeter which will be tested in the DRTF solar furnace. An important objective of this effort is a fundamental understanding of energy loss mechanisms and design guidelines for minimizing them.

The development of experimental devices for the measurement of flux and temperatures in a receiver will be continued. These devices will include adaptation of the Inframetrics 525 video imaging radiometer to the measurement of temperature distribution inside cavity receivers and experimentation with the SERI/GIT multicolor pyrometer. Emphasis will be on using either existing hardware or hardware developed through SERI.

Subtask 3.2, Receiver Development -- In FY86, development will continue on engines for dish electric applications (see Task 4). Receivers will be developed concurrently with each engine to ensure compatibility and an optimized design. Receivers utilizing thermal energy storage or heat pipes will be evaluated on a case-by-case basis.

In the next two fiscal years, receiver/reactors for thermochemical transport will be designed and fabricated. These efforts will be coordinated with those of Task 6.

The development and performance testing of aperture glazings will be continued throughout the year so that the cost benefit tradeoffs of such glazings can be evaluated. Sol-gel coatings will be investigated on a preliminary experimental basis for applicability to aperture glazings and passively cooled terminal concentrators.

Resource Requirements, Task 3

Costs (k$)	FY86	FY87
In-house	590	651
Contracts	331	486
Total costs (k$)	921	1137
Manpower (man-yr)	4.3	4.4

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/ kWe to support the system-level goal of $0.05/kWhe. The interim (five-year) goals are 35% and $1000/kWe. Alternate combinations of cost and performance that provide equivalent cost-effective results would, of course, be acceptable.

Task 4 has been organized into three subtasks: Heat Engine Analysis, Gas and Vapor Power Cycles, and Thermal Electric Converters. 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. Prior-year concepts that remain attractive and more recent opportunities such as the free-piston Stirling engine will be continued. Conceptual studies, designs, hardware development, and testing will take place during FY86 and FY87 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 which show potential for development and for meeting program goals in the mid- and long-term. A computer code developed at SNLA gives performance and economic capabilities for technical analyses and can, also, provide absolute as well as comparative economic estimates. As a result, it constitutes a valuable tool for evaluating heat engine options that meet the solar thermal program goals.

In FY85 SNLA placed a contract with Argonne National Laboratory for a study of reliability and failure mode and effects analysis of selected current and advanced Stirling engines. These include Stirling Thermal Motors STM 4-120, Mechanical Technology Inc. MTI Mod II, and the MTI Space Power Demonstration Engine. The contract includes the transfer of the Argonne-developed SEAM code to SNLA. This activity will be completed by September 1986.

Subtask 4.2, Gas and Vapor Power Cycles -- The first-generation Organic-Rankine-cycle (ORC) engine development for dish-electric systems was completed in FY84. This system uses superheated toluene, which is then expanded through a turbine-alternator- pump (TAP), to generate electricity. Barber-Nichols (B-N) designed and built the current ORC engine under a Ford Aerospace/JPL contract. Upon transfer of the point-focus development program from JPL, SNLA contracted with Barber-Nichols for several hundred hours of hot bench testing and the addition of an automatic control system for the ORC. During FY85, this engine was delivered to SNLA Distributed Receiver Test Facility (DRTF) and integrated with the Test Bed Concentrator (TBC-1) for characterization. During FY86, this characterization will be completed.

A very attractive application of the Stirling cycle is the free piston Stirling engine (FPSE). This engine has the potential for high reliability, long life at low maintenance, and high cycle efficiencies. The FPSE is currently under development by several companies, including Mechanical Technology, Inc. (MTI), Sunpower, Inc., University of Washington, and Energy Research and Generation, Inc. (ERG). MTI, in addition, demonstrated a FPSE for NASA/LeRC under the SP-100 space power program during FY85. Initial results were very encouraging. As a result, SNLA will sponsor, through NASA/LeRC, the conceptual and preliminary design of a solarized FPSE by means of a competitively placed R&D contract(s). An RFP will be released by LeRC in January 1986. Preliminary design is scheduled for late FY86 with detailed design approximately a year later. This work will coincide with LeRC's free-piston Stirling being developed for space. Fabrication and testing of a prototype design would occur in FY88.

The Gas Research Institute (GRI) has been negotiating with Advanco and Stirling Thermal Motors (STM) to develop a gas/solar hybrid capability for a Stirling engine. The DOE has agreed to cooperate with GRI by cofunding such an effort. When such a contract is placed, SNLA will provide technical support to the DOE/AL project office.

The solar community is currently without access to kinematic Stirling engines (KSE). To encourage KSE developers and to provide solar system developers with performance data and solar operating experience, a commercial KSE will be purchased (if available), solarized, and delivered to the DRTF for test and evaluation. An RFP is scheduled for release in June 1986.

A Brayton cycle Advanced Gas Turbine, the AGT-101 is being developed by Garrett Turbine Engine Company through NASA/LeRC for the DOE automotive program. In prior years, JPL secured a commitment from NASA to fabricate a 1600°F AGT for the solar thermal program. This assembly is known as the Solarized Automotive Gas Turbine (SAGT-1A). The SAGT-1A will be delivered to SNLA's DRTF, and will be installed, and tested on one of the test bed concentrators during FY86.

Resource Requirements, Task 4.1 and 4.2

Costs (k$)	FY86	FY87
In-house	644	630
Contracts	881	1280
Total costs (k$)	1525	1910
Manpower (man-yr)	5.2	4.8

Subtask 4.3, Thermal Electric Converters -- Conversion of thermal energy to electricity without the use of machinery with moving parts is highly desirable. Thermally regenerative electrochemical systems (TRES), capable of achieving thermal to electric conversion without the use of major moving parts, have the potential for significantly reducing the O&M costs for heat engines. The objective of this task is to engineer and develop promising energy conversion devices applicable to solar thermal systems and to conduct the necessary studies to determine the TRES options with the most potential. Two thermally regenerative electrochemical systems under consideration in this task are the Liquid Metal Thermal Electric Converter (LMTEC), currently under development in-house, and the Recirculating Thermal Electrochemical Converter (RTEC).

As a result of a study comparing presently available and long-term engines the LMTEC was chosen as one of the most promising technologies for dish-electric applications. Projected peak efficiency for a LMTEC using mercury as the working fluid is 40% at 800°C. This value puts the annual efficiency of a mercury LMTEC based solar power plant in the 25%+ range at temperatures and performance achievable with present-day concentrator and receiver technology.

Current LMTEC technology relies upon Beta" Alumina Solid Electrolyte (BASE), a fast ion conductor material across which a pressure differential is maintained for the expansion of the liquid metal working fluid. The ionization necessary for the expansion of the working fluid requires the use of a porous electrode on the low pressure side which can allow for ionic and atomic diffusion of the metal prior to vaporization and condensation in the working cycle. The use of an electromagnetic pump to recirculate the working fluid renders the LMTEC free of moving parts and allows for virtually no maintenance, high reliability, and durability.

Recently Sandia has endeavored to evaluate the LMTEC technology and compare it to current and near term dish-electric alternatives. Performance projections have shown the need to develop a mercury-exchanged BASE because using mercury as the working fluid will allow for operation at lower temperatures with higher efficiencies.

In carrying out the objectives and goals of this task, plans for FY86 and FY87 are to conduct the necessary experimentation and analyses to design a 20-50 kWe LMTEC suitable for use on a dish system. The near term plan is to:

- Accelerate the development of an electrolyte suitable for the Hg LMTEC.
- Design, fabricate, and test modules at the 100-W level.
- Perform materials and components experiments on this module.
- Conduct the necessary materials and component development to support all aspects of this task.

Resource Requirements, Task 4.3

Costs (k$)	FY86	FY87
In-house	700	720
Contracts	250	600
Total costs (k$)	950	1320
Manpower (man-yr)	5.0	4.8

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 (SEN) heat transport methods at the medium to low temperature range 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 (DR) applications. Sensible energy transport at temperatures of 400°C or higher costs a significant percentage of the collected energy in transport losses to deliver the energy to the use point. 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 five-year and long-term goals for transport and storage systems are 85% efficiency at 90 $\$/m^2$ and 90% efficiency at 50 $\$/m^2$, respectively.

Activities during FY84 focused on investigating and evaluating potential chemical systems for TC energy transport. The two that appeared most promising for high-temperature dish applications were identified as sulfur trioxide dissociation and carbon dioxide reforming of methane. Small-scale laboratory experiments with these two systems were completed in FY85. They provided good, but limited, performance data and indicated several problem areas. The principal concerns were identified as the resistance of structural materials to environmental attack with combined thermal and mechanical cycling in the SO_3 system, and the development of suitable catalysts for the reforming and methanation ends of the CO_2/CH_4 system.

Current Task 6 activities include complimentary modelling and experimental studies that will culminate in demonstrating the practical feasibility of TC energy transport for distributed-receiver applications.

Status and Planned Activities

Subtask 6.1, Code Development -- The model development activity is aimed at obtaining the necessary computational tools for making performance/economics evaluations of SEN and TC energy transport systems for applications.

The initial version of the closed-loop efficiency analysis (CLEA) code, a single-loop, steady state performance model, is nearing completion. Models of both the endothermic and exothermic ends are currently operating separately. In FY86 these will be coupled to produce a closed-loop TC energy transport model for four chemical systems: CO_2/CH_4, H_2O/CH_4, SO_3, and NH_3. Once the closed-loop model is operational it will be documented in a users guide report. The next phases of this activity will be to extend the code to include, first, costing algorithms and, second, transient operation of the loop.

A distributed receiver collector field energy transport system performance/economics model is being developed for both SEN and TC systems and steady-state and transient operating conditions. The approach is to modify an existing steady-state SEN energy transport code (such as SOLTES or ETRANS) by incorporating models for TC transport and economics (if necessary) and extending to transient operations. Activities in FY86 will concentrate on developing an algorithm for solving the endothermic and exothermic TC transport reactions (equilibrium chemistry), including all relevant side reactions and condensible species, for the candidate chemical systems (CO_2/CH_4 and SO_3). Once this has been accomplished, the algorithm will be incorporated into an initial version of a dish-field TC energy transport steady-state performance code.

Subtask 6.2, SO_3 Dissociation -- A scaled-up (10 kW) closed-loop SO_3 dissociation facility has been constructed at Physical Science Laboratory, New Mexico State University (PSL/NMSU). During FY86 a second dissociator, of a different design, will be added and the complete TC transport loop will be operated under steady-state and simulated solar transient conditions. Major concerns to be investigated include receiver/reactor design, manifolding and flow control with two reactor/heat exchanger elements per receiver and with two dissociators, operating procedures and control strategies under steady, transient, and part-load operation, techniques and procedures for preventing SO_3 condensation in the lines, and synthesizer calorimetric measurements. These experiments will be completed in mid FY86.

Materials corrosion experiments are being continued to determine what construction materials are most resistant to oxidation/sulfidation environments characteristic of an SO_3 thermochemical transport system. Candidate materials are exposed to representative environments ($SO_3/SO_2/O_2$ gas mixtures at temperatures of 500°

and 900°C) for extended periods of time at steady conditions and also under cyclic conditions. Tests scheduled for FY86 are: two-month, constant temperature tests (at 500° and 900°C) in SO_3 gas; and one- and two-month cycle temperature tests (temperature cycled between 900° and 1000°C) in SO_3. These tests will be completed by mid FY86.

Mechanical properties experiments will be continued to select alloys suitable for use in the high-temperature, corrosive environments in the receiver/reactor units of an SO_3 thermochemical transport system. During FY86 constant load creep tests and welding experiments will be performed on candidate materials using as-received and aged specimens to determine high-temperature mechanical properties, weld-cracking characteristics, and postservice weldability of dissociator elements. These tests should be completed by mid FY86.

Subtask 6.3, CO_2/CH_4 Reforming -- Experiments will be continued during FY86 in the closed-loop efficiency analysis thermochemical energy transport facility at SNLA. This facility is a laboratory-scale (2.5 kW) closed-loop system based on the CO_2/CH_4 reforming/methanation concept. It employs a single reformer and a single methanator. It will be operated under steady-state and simulated solar conditions to demonstrate the technical feasibility of TC transport. Initial tests will be conducted at a reformer temperature of 750°C. The facility will subsequently be upgraded to operate at a reformer temperature of 1000°C. Steady-state and transient tests at this temperature should be completed by the end of FY86.

A contract has been placed with the University of Houston to support the closed-loop experiments through the procurement and evaluation of carbon-resistant, commercially available catalysts, and the development of new catalysts, for both reforming and methanation. During FY86 the University of Houston will continue experiments to determine the activity and selectivity of candidate catalysts and provide promising catalysts for testing in the SNLA facility. In addition, a reforming catalyst will be tested in the University of Houston 25-kW reformer.

Mechanical properties experiments will be performed in FY86 to examine the creep characteristics of candidate alloys in representative CO_2/CH_4 reforming environments.

Subtask 6.4, Field-Scale Experiment -- The follow-up to the modelling and experimental activities described above, assuming favorable results, is to demonstrate the practical feasibility of TC energy transport at larger than laboratory-scale and under more realistic conditions. This will consist of a field-scale experiment involving four receiver/reactors, sized for about 100 kW_{th}, one exothermic reactor, an appropriate piping network, and commercially available components to the extent possible. The experiment will be located at the DRTF and DRTF personnel will provide support during the design, construction, and testing phases. Detailed design of the DRTF thermochemical field experiment will be completed in September 1986. Construction will be completed about one year later.

The chemical system to be employed will be selected in January 1986. The remainder of the fiscal year will be devoted to preparing preliminary and detailed designs of the field-scale experiment.

Resource Requirements, Task 6

Costs (k$)	FY86	FY87
In-house	784	780
Contracts	436	608
Total costs (k$)	1220	1388
Manpower (man-yr)	5.6	5.2

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 field wiring and protection, interfaces between solar systems and their applications, safety, etc.

Status and Planned Activities

The primary technology requirement in the Balance-of-Plant task for distributed receiver solar thermal systems is the development of economical and reliable control systems. The initial activities will include a study of the state-of-the-art of current commercial control system hardware and strategies. A comparison of these findings with solar energy system requirements and cost goals will form the basis for planning an R&D approach. This work will be completed by June 1986. Liaison will be maintained with the automated control system development being conducted in the central receiver program, with emphasis on the adaptability of that work to distributed receiver systems. These efforts will permit an accurate assessment of the status and needs for distributed receiver control systems, as well as other Balance of Plant needs, in early FY87. This assessment will in turn be used to define the scope of an RFP for control systems development which will be issued in mid-FY87.

Resource Requirements, Task 8

Costs (k$)	FY86	FY87
In-house	42	150
Contracts	0	40
Total costs (k$)	42	190
Manpower (man-yr)	0.3	1.0

R&D TASK 10, DISTRIBUTED RECEIVER SYSTEMS

The objective of this task in the Distributed Receiver Project is to perform the systems level engineering and analytical work needed to direct the developing component technologies. Such responsibility extends from identification of industry needs to technical feasibility. Thus, the task defines the requirements and constraints for systems through performance and economic studies. These activities, through both in-house efforts and outside contracts, will provide conceptual designs of systems and subsystems. 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.

Status and Planned Activities

Subtask 10.1, Systems Engineering and Analysis -- The development of a code to aid in examining large parabolic dish fields was initiated in FY85. The purposes of this activity are (1) to develop in-house capability to look at large distributed receiver fields with centrally located point of energy delivery (either sensible heat or thermochemical) and (2) to pull together the various ongoing component modeling activities. Each component currently models those other components with which it interacts in varying ways. This code development will be completed in January 1986.

The above code development will be used to complete the Central Engine Study. Current available tools will be used to complete a Phase I quick look at the central engine concept. As the system model develops, more sophisticated analyses will be undertaken to refine assumptions in the study. The central engine study will examine systems in the 500 kW to 50 MW range over a 400°C–650°C temperature range. As part of this activity a contract to identify available Rankine engines, as well as mid- and long-term industry projects, has been placed with MTI. No DOE engine development is contemplated. This task will continue into FY87 with a conceptual design of the most promising combination within this range that will provide the lowest levelized energy cost.

A base case for the central engine concept and for the dish/electric concept will also be developed. It will consist essentially of components functioning at existing technology levels. It is planned that current capabilities will be modelled after the LaJet Solar Plant I and Advanco/Vanguard project, provided enough operating data are available from each. The base case must represent existing hardware to be useful as a point of departure for future component development.

University of Chicago researchers have developed heat transfer models to predict more accurately the heat distribution on a trumpet-shaped terminal concentrator. When used with a ray trace code (developed at the University also), both normal tracking and misaligned cases may be analyzed. In FY86 engineering development of terminal concentrators based on the thermal analyses and optics developed at the University of Chicago (see Task 10) will be conducted. The goal will be to significantly improve concentration ratio without a requirement for active cooling.

A trade-off study to examine the concentrator/receiver interface will begin in FY86. This analysis should enhance inhouse capabilities in the areas of flux delivery on internal cavity receivers and heat loss effects on receiver performance. The study will also investigate the tradeoffs associated with terminal concentrators.

An effort, in conjunction with the heat engine task, will examine the hybridization of single-dish engines. A preliminary heat engine assessment indicated the potential of the small hybrid dish-mounted engine, but information on hybrid engine cost was limited. The economics advantages of increasing dish-electric capacity factors were not included. A hybrid system study will be initiated in late FY86 with first phase completion scheduled for late FY87.

Application analyses for high-temperature thermal energy is scheduled for early FY87. Past industry-use surveys will be assembled and updated to identify market possibilities.

SERI is currently investigating high-temperature chemical waste detoxification. Some engineering development assistance may be appropriate in FY87. Liaison with SERI will be maintained in FY86.

Resource Requirements, Subtask 10.1

Costs (k$)	FY86	FY87
In-house	448	510
Contracts	119	720
Total costs (k$)	567	1230
Manpower (man-yr)	3.2	3.4

Subtask 10.2, Distributed Receiver Test Facility (Operation and Maintenance) -- The Distributed Receiver Test Facility (DRTF) was activated in 1984. The test bed concentrators (TBC-1 and TBC-2) were moved from JPL's parabolic dish test site at Edwards Air Force Base and are now both operational at Albuquerque. The LaJet concentrator (LEC-460) has been installed and is operational. These facilities will be used to test the SAGT and ORC engines, the SCSE modules, and the concentrators procured under the Innovative Concentrator Program.

The rotating platform from the Collector Module Test Facility was relocated to the DRTF during FY85 and its instrumentation, checkout, and initial operation will occur in early FY86. The platform as well as the line-focus qualification test systems installed during the MISR project will be used to test improved line-focus components.

The DRTF will be maintained and operated as required to support testing by the various tasks. Test requirements and resources to support specific tests are included under the relevant task descriptions. Resources for Task 10.2 support maintenance, operations, and upgrade of the facility.

The facility will be used, also, to conduct reimbursible tests for other programs and laboratories in a basis of non-interference with solar thermal test requirements.

Resource Requirements, Subtask 10.2

Costs (k$)	FY86	FY87
In-house	187	180
Contracts	195	175
Total costs (k$)	382	355
Manpower (man-yr)	1.7	1.5

Subtask 10.3, Evaluation of Field Experiment Projects -- The objective of this subtask is to evaluate the performance and operational experiences of any field experiments involving distributed receiver technology and to make the results of such evaluation available to the solar community. The above projects include the Shenandoah Solar Total Energy Project, the Industrial Process Heat Projects, and such privately funded and non-solar thermal funded projects as the Luz plant near Barstow, CA, the LaJet plant near Warner Springs, CA, the Gould Battery Plant in Chandler, AZ, and the IEA's Small Solar Power System near Almeria, Spain. Technical consultation will also be furnished at a modest level to the project operators to try to improve performance or reduce operating and maintenance costs.

In FY85 a set of 29 Test Operation Phase (TOP) experiments was performed at the Shenandoah project. The experiments were designed to evaluate the performance of the Shenandoah facility. Evaluation of the TOP experimental results is presently underway and scheduled for completion by December 1985. A cooperative agreement between DOE and Georgia Power Co. (co-owner operator) has been completed. Ownership of the Shenandoah facility was transferred to Georgia Power effective September 1985. A Sandia contract has been placed with the Georgia Power Co. to perform a set of experiments directed toward continuous operations. The continuous operations experiments are scheduled to be performed by December 1985. Evaluation of the continuous operations experiments is scheduled to be completed by December 1986. Development testing of subsystems and components is planned for 1986-87 at the Shenandoah site to supplement the activities presently being conducted by Georgia Power personnel. Examples of things currently being developed include modifications to the control and instrumentation subsystem to improve tracking, better software programs to reduce stress on equipment, and use of integrated circuit hardware to improve the accuracy of temperature and flow measurement and to control motors on pumps and blowers to reduce electrical parasitic losses. Sandia will provide for the evaluation of the experiments by in-house activities and through contracts placed with California Polytechnic University.

The DOE phase of the IPH project was completed in August 1985. During FY86 Sandia will continue to monitor IPH systems that are operated by their owners and will document and report energy production and operation and maintenance experience. This information will be reported quarterly and annually.

Resource Requirements, Subtask 10.3

Costs (k$)	FY86	FY87
In-house	140	120
Contracts	120	80
Total costs (k$)	260	200
Manpower (man-yr)	1.0	0.8

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 to be located at Osage City, KA, and the other on Molokai Island, Hawaii. 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. Module Verification
2. Solar Plant Design
3. Solar Plant Installation
4. Solar Plant Operation and Maintenance

In the two years described by this plan, verification testing will be conducted at the DRTF, the SCSE at Osage City will be designed and fabricated, and the SCSE will be installed, checked out and started up at Osage City. Operation of the plant will commence in FY87. The schedule for SCSE#2 at Molokai is being negotiated between DOE/AL and PKI. It will lag SCSE#1 by about a year.

The site for SCSE 2 on Molokai is dependent upon negotiation of a cooperative agreement between DOE/AL and the site participant.

Sandia's responsibility will be 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 will be maintained with the responsible contractors.

Resource Requirements, Task 11

Costs (k$)	FY86	FY87
In-house	210	300
Contracts	40	570
Total costs (k$)	250	870
Manpower (man-yr)	1.5	2.0

CHAPTER 4. RESOURCES AND IMPLEMENTATION

This chapter provides summary information in several formats for the FY86 and FY87 plans for SNLA's Solar Thermal Projects. This information includes:

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

Major Milestones for FY86 and FY87

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. The deliverables for FY86 and FY87 are listed in Table 4.1.

Resource Requirements Summary

The manpower and budgetary resources required for the plans described in Chapter 3 are summarized in Table 4.2. 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.

Capital Equipment

The capital equipment needed to support distributed receiver research and development is: (1) a cooling tower and data acquisition and handling system for the DRTF, (2) an electric furnace for the receiver test facility, and (3) a traveling crane, cooling tower, and exhaust fans for the engine test facility. A capital equipment budget of $100K is being requested for commitment in FY86.

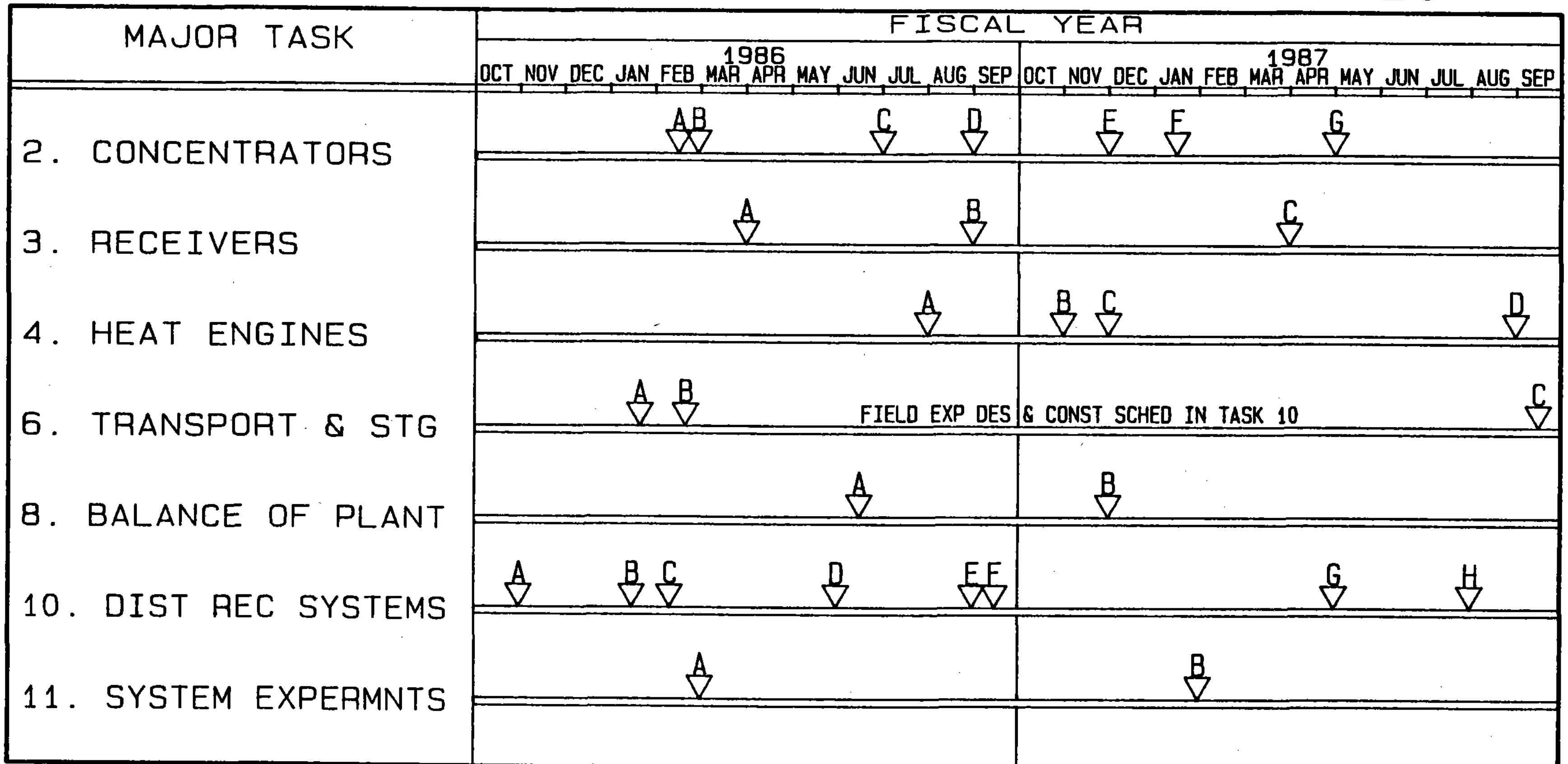
Management Plan

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

Status and Planned Activities -- 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 2-year Sandia (SNLA) Development Plan on an annual basis.

Project reporting is conducted at several levels. Within the federal Solar Thermal Technology Program community, 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.

DISTRIBUTED RECEIVER DEVELOPMENT PROJECT



2. CONCENTRATORS:
- A= COMPL IC DETAIL DESIGN REVIEWS (DOE/AL)
- B= FINALIZE AG/SOL-GEL PROCESS DEV
- C= AWARD STR MEMB CONCEPT CONTRACTS
- D= COMPL SNLA CONC PRELIM DESIGN
- E= FAB AG/SOL-GEL STR MEMB FACET
- F= FINAL IC TO DRTF FOR TESTING
- G= COMPL SNLA CONC DETAIL DESIGN

3. RECEIVERS:
- A= HELIOS CONC/REC CODE OPERATNL
- B= COMPL TC RCVR DETAILED DES
- C= DELIVER TC RCVR TO DRTF FOR TEST

4. HEAT ENGINES:
- A= COMPL 1ST LMTEC BENCH MOD TEST
- B= COMPL FPSE CONCEPTUAL DESIGN
- C= ESTAB FEAS OF LMTEC HG ELECTROLYTE
- D= COMPL FPSE DETAIL DESIGN

6. TRANSPORT & STG:
- A= SELECT TC SYST FOR FIELD-SCALE EXPR
- B= COMPL CONCEPT DES TC FIELD EXPR
- C= BEGIN TC FIELD-SCALE EXP C/O & STARTUP

8. BALANCE OF PLANT:
- A= COMPL COMMERCIAL CONTROLS STUDY
- B= COMPL CONTROLS DEV NEEDS ASSESSMT

10. DIST REC SYSTEMS:
- A= COMPL QUICKLOOK CNTRL ENG STUDY
- B= ROTATING PLATFORM OPERTNL AT DRTF
- C= COMPL SHENANDOAH CONT OPRNS EXP
- D= OCCUPY DRTF ENG TEST FACILITY
- E= COMPL ENGINE AVAIL CONTRACT
- F= COMPL DETAIL DES DRTF TC FIELD EXPR
- G= COMPL PHII OF CNTRL ENG STUDY
- H= COMPL CONST DRTF TC FIELD EXPR

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

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Table 4.1

Deliverables for FY86 and FY87

Date	Title
Dec 85	"CLEA: The Closed Loop Efficiency Analysis Test Facility for Thermochemical Energy Transport Studies" (6.3)
Dec 85	Shenandoah TOP evaluation report (by GPC) (10.3)
Mar 86	"A Scaled-Up, Closed-Loop Sulfur Oxide Energy Conversion and Transport System" (6.2)
Mar 86	"Users' Guide for the CLEA Code: A Performance Model for Thermochemical Energy Transport" (6.1)
Mar 86	Shenandoah computer modelling report (by SERI) (10.3)
Jun 86	"Final Report on Catalyst Development for CO_2/CH_4 Reforming and Methanation" (by U of H) (6.3)
Jun 86	Conference, Solar Thermal Technology Annual Conference, Albuquerque, NM
Jul 86	Report of high-specific-power electrode develoopment (by JPL) (4.3)
Jul 86	"Balancing Methanation and CO_2/CH_4 Reforming Reaction Systems for Thermochemical Energy Transport" (6.3)
Aug 86	Report of design and test of 100-w LMTEC model (4.3)
Aug 86	Rankine Engine Availability report (by MTI) (10.1)
Sep 86	FMEA study analysis report (by ANL) (4.1)
Sep 86	Contractor report of mercury BASE material development (4.3)
Sep 86	Contractor report, users manual for Inframetrics 525, video imaging radiometer (by Clarkson U) (3.1)
Oct 86	FPSE conceptual design report (4.2)
Dec 86	Test-bed receiver final report (3.2)
Dec 86	"Thermochemical Energy Transport Based on the CO_2 Reforming of Methane: Results of the CLEA Experiments" (6.3)
Dec 86	Shenandoah continuous operating report (by GPC) (10.3)
Jun 87	Conference, Solar Thermal Technology Annual Conference, Albuquerque, NM
Jul 87	FPSE detailed design report (4.2)

Table 4.2

Resource Requirements Summary

Distributed Receiver Development Project -- FY86 and FY87

	FY 1986				FY 1987			
	In-house		Contracts	Total	In-house		Contracts	Total
	MY	$k*	$k	$k	MY	$k*	$k	$k
Collection Technology								
2.0 Concentrators	4.7	600	1365 **	1965	5.0	675	1285 ***	1960
3.0 Receivers	4.3	590	331	921	4.4	651	486	1137
Energy Conversion Technology								
4.0 Heat Engines	10.2	1344	1131	2475	9.6	1350	1880	3230
6.0 Transport and Storage	5.6	784	436	1220	5.2	780	608	1388
8.0 Balance of Plant	0.3	42	0	42	1.0	150	40	190
Systems and Applications Technology								
10.0 Distributed Receiver Systems	5.9	775	434	1209	5.7	810	975	1785
11.0 Systems Experiments	1.5	210	40	250	2.0	300	570 ****	870
Capital Equipment			100	100			150	150
TOTALS	32.5	4345	3837	8182	32.9	4716	5994	10710

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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.

**Includes $865k in DOE/AL funding in Task 2, Concentrators.

***Includes $400k in DOE/AL funding in Task 2, Concentrators.

****Includes $500k in DOE/AL funding in Task 11, Systems Experiments.

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.

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 electric technology in the range of tens to hundreds of kilowatts.

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 4.3 provides a list of those new procurements that are anticipated in FY86. Table 4.4 lists the major active contracts placed on FY85 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.

Unsolicited Proposal Funding -- Sandia, through its prime contract held by AT&T Technologies with the U.S. Department of Energy, is excluded from funding unsolicited proposals which have been submitted to the Laboratory. These proposals are returned unopened with instructions regarding the proper route of submittal to DOE/HQ. Once such a proposal is submitted through the proper channels, reviewed, and accepted for funding by the appropriate Division Director (DOE/HQ), SNLA can place the contract as a result of a written request from that Director. In implementing this procedure, Headquarters and SNLA will reach an agreement regarding the source of funding prior to a formal request being sent to SNLA to place a contract. It is expected that most approved unsolicited proposals will be of sufficient value to fit within the scope described in this plan and will not require additional funding. Exceptions will occur where the proposals are approved using additional criteria and where funds have been reserved at Headquarters for funding such proposals.

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.

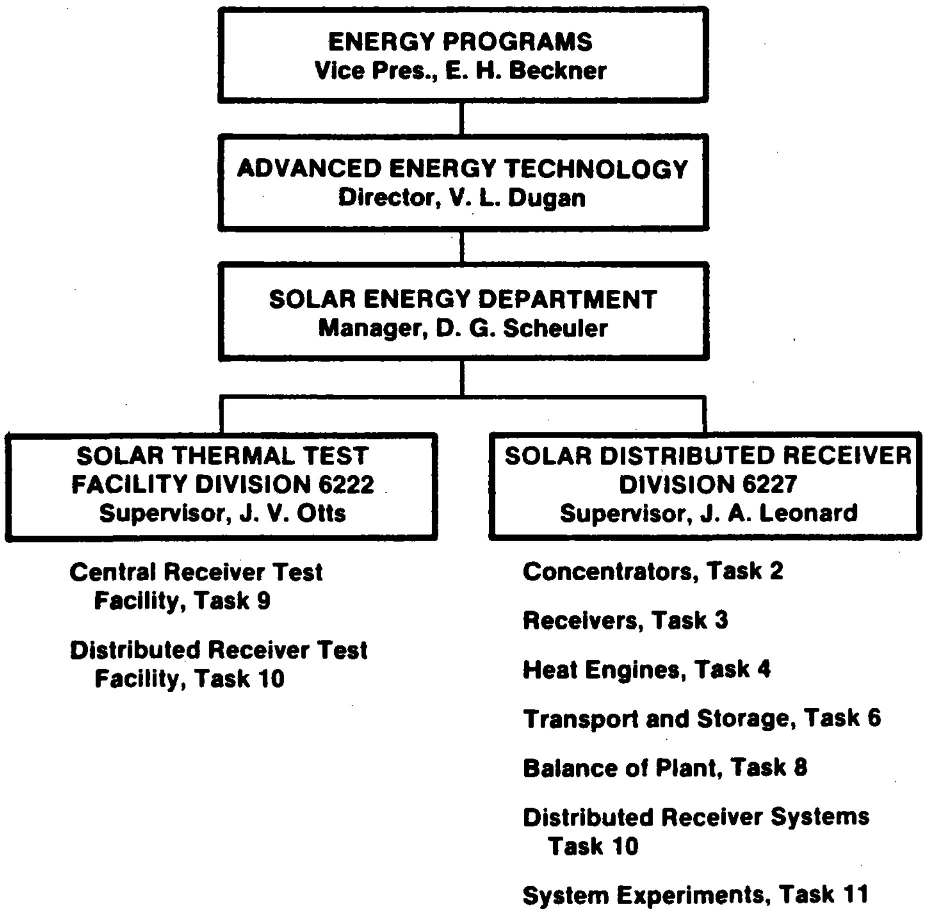

Figure 4.2. Organizational Structure for SNLA's Solar Thermal Projects

TABLE 4.3

PROCUREMENT SUMMARY FOR FY86
MAJOR ANTICIPATED CONTRACTS

TITLE	TASK	AMOUNT	PROJ. ENGR.	START	COMPLETE
INNOVATIVE CONCENTRATOR (DOE/AL)	2.2	865	T. MANCINI	JAN. 86	MAR. 87
POINT-FOCUS CONCENTRATOR DEV.	2.2	450	T. MANCINI	OCT. 86	SEPT. 87
STRUCTURAL MIRROR DEV.	2.2	50	T. MANCINI	JUNE 86	JAN. 88
STRETCHED MEMBRANE REFLECTOR CONCEPTS	2.2	400	T. MANCINI	JUNE 86	MARCH 87
HEAT ENGINE RECEIVERS	3.2	300	R. DIVER	APR. 86	SEPT. 87
THERMOCHEMICAL TRANS. RECEIVERS	3.2	50	R. DIVER	MAR. 86	JULY 87
ENGINE TECHNOLOGY ANALYSIS	4.1	250	K. LINKER	JAN. 86	DEC. 86
ORC ENGINE EVALUATION	4.2	30	K. LINKER	OCT. 85	FEB. 86
FREE PISTON STRLG ENGINE DESIGN	4.2	450	K. LINKER	JUNE 86	SEPT. 87
SAGT-1 TEST AND EVALUATION	4.2	40	K. LINKER	NOV. 85	MAR. 86
ENGINE/RECEIVER TEST FACILITY	4.2	190	S. MURPHY	NOV. 85	MAR. 86
HG ELECTROLYTE DEVELOPMENT	4.3	200	J. MARTINEZ	OCT. 85	SEPT. 86
LMTEC DEVELOPMENT	4.3	50	J. MARTINEZ	JUNE 86	JUNE 87
SO3 EXPERIMENTS	6.2	45	J. MUIR	JAN. 86	SEPT. 86
CATALYST DEVELOPMENT	6.3	50	J. MUIR	JUNE 86	SEPT. 87
MATERIALS CARBURIZATION	6.3	130	J. MUIR	FEB. 86	MAR. 87
DETAIL DESIGN, TC FIELD EXPRMT.	6.4	70	C. CAMERON	APR. 86	SEPT. 86
ENGINEERING PROGRAMMING SUPORT	10.1	175	M. FEWELL	NOV. 85	DEC. 87
DRTF A&E SUPPORT	10.2	195	C. CAMERON	NOV. 85	SEPT. 86
SHENANDOAH TECHNICAL SUPPORT	10.3	80	A. HECKES	JAN. 86	JUNE 87
DATA REDUCTION & REPORTS, SCSE 1 & 2	11.1	30	E. RUSH	OCT. 85	SEPT. 86

TABLE 4.4

MAJOR PROCUREMENT SUMMARY
ACTIVE CONTRACTS PLACED ON
FY85 BUDGET AUTHORITY

CONTRACTOR	TASK	CONTRACT TITLE	VALUE	TYPE	PROJ. ENGR.	PO/PR	COMPLETE	REMAIN BAL
SOLAR KINETICS, INC.	2.0	LINE-FOCUS RECEIVER DEV.	32	SMALL	T. MANCINI	64-4680	3-31-86	22
UNIVERSITY OF NEW MEXICO	2.0	BO-NI EXPLORATORY CHEMIST	23	UNIV	C. BALFE	51-0623	6-30-86	10
SOLAR KINETICS, INC.	2.0	GLASS LAMINATE DEV.	13	SMALL	T. MANCINI	64-4676	3-31-86	7
ACUREX	2.0	LINE FOCUS COMP. DEVELOPM	96	SMALL	T. MANCINI	21-0800	3-31-86	41
CUSTOM ENGINEERING	2.0	LINE-FOCUS CONTROLS DEV.	42	SMALL	T. MANCINI	64-4677	3-31-86	8
SOLAR KINETICS, INC.	2.0	DISH DEVELOPMENT	499	SMALL	T. MANCINI	21-3695	3-31-86	121
CLARKSON UNIVERSITY	3.0	TEMPERATURE MAPPING TOOL	20	UNIV	R. DIVER	32-3242	7-1-86	17
ARGONNE NL	4.1	STIRLING FMEA ANALYSIS	220	GOVT	K. LINKER	32-7644	9-30-86	220
BLACK AND VEATCH	4.2	DESIGN ENGINE TEST LAB	30	LARGE	K. LINKER	64-9464	10-31-85	30
UNIVERSITY OF WISCONSIN	4.3	HG-BETA-ALUMINA STUDY	50	UNIV	W. HAMMETTER	95-2054	9-1-86	42
UNIVERSITY OF PENNSYLVANIA	4.3	HG-BETA-ALUMINA RESEARCH	49	UNIV	W. HAMMETTER	64-9240	6-30-86	49
JET PROPULSION LABORATORY	4.3	ELECTRODE DEVELOPMENT	100	GOVT	J. MARTINEZ	64-9358	3-15-86	98
NEW MEXICO STATE UNIV.	6.0	THERMOCHEM ENERGY TRANS	90	UNIV	J. MARTINEZ	21-3683	11-30-85	14
UNIVERSITY OF PITTSBURGH	6.0	CORROSION OF ALLOYS	50	UNIV	L. WEIRICK	64-1068	4-30-87	40
UNIVERSITY OF HOUSTON	6.0	CATALYSIS RESEARCH	50	UNIV	J. FISH	64-3924	9-30-85	37
UNIVERSITY OF CHICAGO	10.1	TERMINAL CONCENTRATOR	66	UNIV	J. DIGGS	59-4826	10-31-85	17
TBD	10.1	SOLAR ENGINE AVAILBLTY ST	200	TBD	J. DIGGS	64-7930	NOT PLACED	200
UNM (NMERI)	10.1	TECHNICAL SUPPORT	80	UNIV	J. LEONARD	64-9556	5-31-87	67
JET PROPULSION LABORATORY	10.1	ENGINEERING SUPPORT	400	GOVT	J. DIGGS	25-7651	10-31-85	278
EG&G	10.2	SOLAR TEST SUPPORT	590	LARGE	C. CAMERON	52-5653	7-31-85	402
BLACK AND VEATCH	10.2	A AND E SERVICES	128	LARGE	C. CAMERON	58-3544	7-31-85	23
DOW CORNING	10.3	SYLTHERM HTF PROCUREMENT	70	LARGE	A. HECKES	32-3455	8-31-85	70
GEORGIA POWER	10.3	SHENANDOAH OPERATIONS	100	LARGE	A. HECKES	64-4689	12-31-85	13
SERI	10.3	SHENANDOAH EVALUATON	50	GOVT	A. HECKES	59-5022	3-31-86	29
CALIFORNIA POLYTECHNIC	10.3	STEP EVALUATION	60	UNIV	A. HECKES	47-7666	2-28-86	21
TECH REPS INC.	10.3	TECH SUPPORT SERVICES	50	SMALL	E. HARLEY	32-6527	9-30-86	50