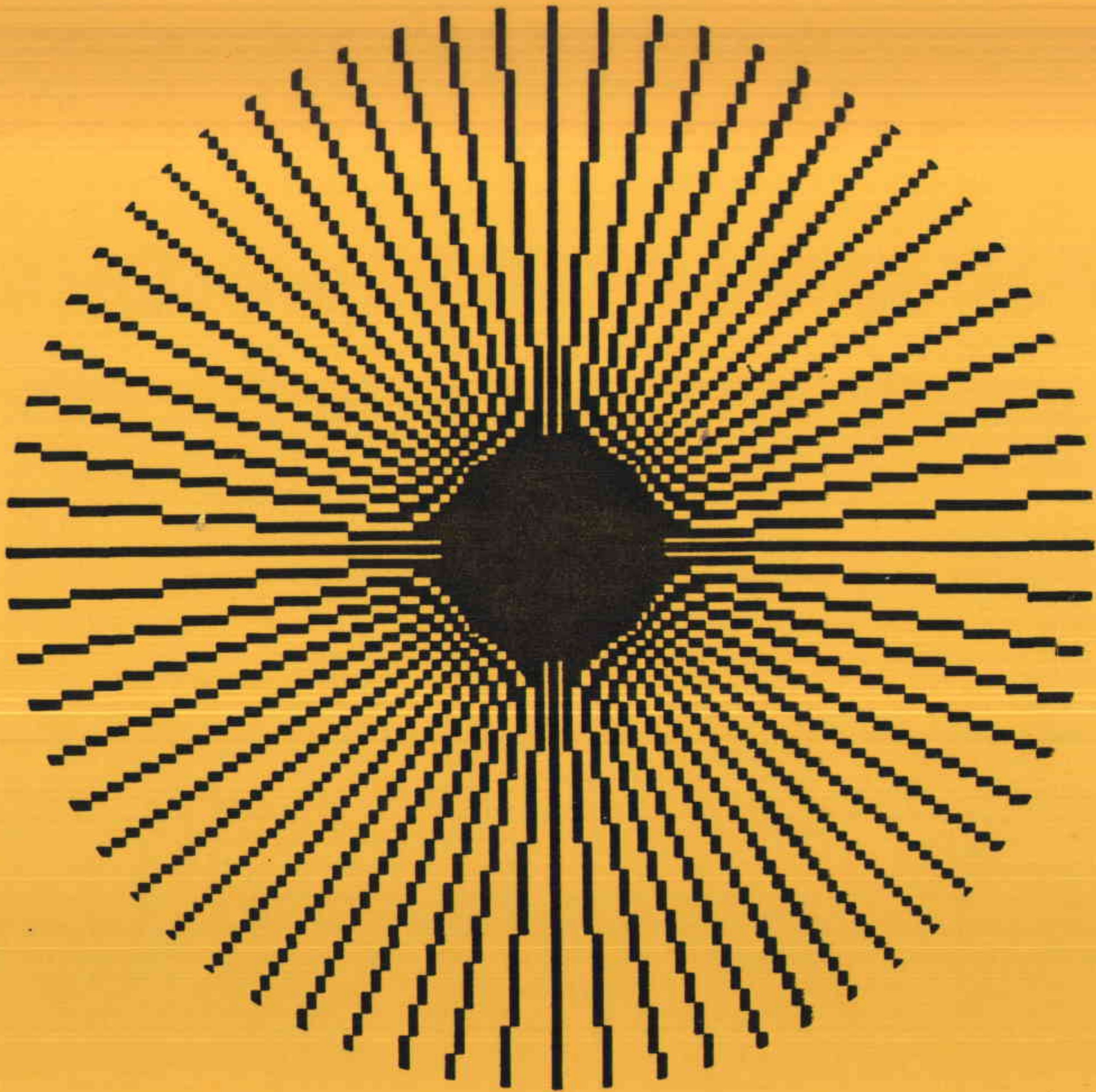
Distributed Receiver Development Plan 1985-1986

Sandia National Laboratories
Albuquerque



Department of Energy
Solar Thermal Technology Program

DISTRIBUTED RECEIVER DEVELOPMENT PLAN

1985-1986

Solar Energy Department
Sandia National Laboratories
Albuquerque, New Mexico 87185
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CHAPTER 1. INTRODUCTION

This document presents the Distributed Receiver Development Project Plan for Fiscal Years 1985 and 1986 for Sandia National Laboratories, Albuquerque, New Mexico. The overall Program Plan for the Department of Energy's (DOE's) Solar Thermal Technology Program is presented in the Five Year Research and Development Plan [1] which describes the purpose and strategy of the Solar Thermal Program, outlines its technical approaches and its organization, and broadly describes the actual research and development activities which constitute the program. The most important features of the Five Year Research and Development Plan are:

- Definition of the overall Solar Thermal Technology Program goals and strategy.
- Organization of the program into a structure of 11 technical R&D activity areas.
- Identification of the three major Field Centers responsible for the implementation of the program.
- Assignment of the task of detailed program planning to these three Field Centers.

The organization of the program is depicted in Figure 1.1.

The detailed program planning is conducted on an annual basis by the three major Field Centers: SNLA, SNLL, and SERI. These Field Centers each prepare and publish their individual planning documents describing detailed plans for the next 2 years. Thus, the actual R&D activities for any year are planned at least a year in advance, and revised to the extent appropriate just before they are implemented. Some additional R&D activities are conducted directly by DOE Operations offices. Plans for the support of these activities are included in the detailed 2-year plans prepared by the three major Field Centers.

This document is the detailed program plan for SNLA's Solar Thermal Projects for FY85 and FY86, and it includes plans for activities conducted by the Albuquerque Office of DOE.

For the sake of completeness, this document contains a brief summary of the Five Year Research and Development Plan in the next chapter.

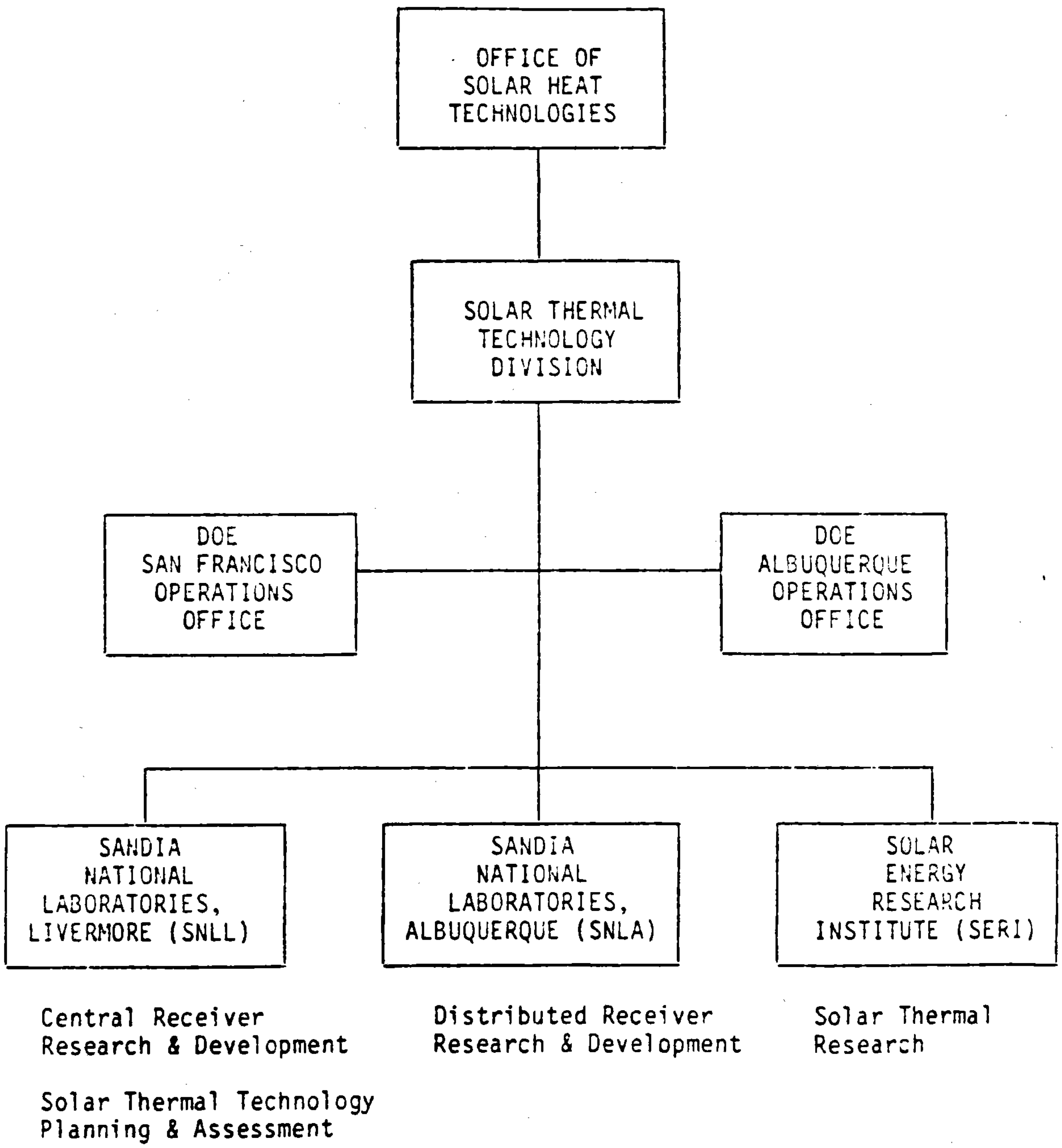


Figure 1.1 Solar Thermal Technology Organizational Structure and Responsibilities

The detailed R&D activity plans for FY85 and FY86 are described in Chapter 3. These plans include activity descriptions, schedules, resource (manpower and funding) requirements, expected results, and explanatory narrative text.

Chapter 4 is the final chapter of this document. It contains a description of the organization of SNLA's Solar Thermal Projects, a discussion of the relationship of SNLA's projects with those of the other two major Field Centers, and a summary of Major Milestones and Resource Requirements for FY85 and FY86. It also includes tables of the major procurements and project deliverables that are planned in FY85.

The DOE budget for Solar Thermal Distributed Receiver Development is limited in relation to the actual R&D needs for this rather new alternate energy technology. Consequently, the plans are sharply focussed on those technical areas considered to be most critical for the development of this technology.

The most critical research and development needs for distributed solar thermal technology are concentrator development and heat engine development. Thus, these plans place a heavy emphasis, including over half of the project's resources, on these two task areas. Other important R&D activity areas include receiver development and systems engineering, to which an additional 20% of the resources are allocated. In all, about three-fourths of the efforts described focus on these primary R&D needs, with the remainder of the funds being used to support direct conversion research, thermochemical transport, optical materials research, and systems experiments.

CHAPTER 2. SOLAR THERMAL TECHNOLOGY PROGRAM AND PLAN

This chapter briefly summarizes the overall DOE Solar Thermal Technology Program as described in the Five Year Plan [1].

The purpose of the Solar Thermal Technology Program is to develop an alternative source of affordable and abundant 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. This work complements that done by private industry and will provide technically proven options for eventual incorporation into the nations's energy supply.

Actual implementation of the Solar Thermal Technology Program is carried out through three research and development Field Centers. These centers are the Solar Energy Research Institute (SERI) in Golden, Colorado, and the Sandia National Laboratories in Livermore (SNLL), California and Albuquerque (SNLA), New Mexico. The specific area of responsibility for SNLL is central receiver technology and for SNLA is distributed receiver technology. SERI's role is the research of materials and innovative concepts for solar thermal technology.

Sandia's responsibilities have included solar thermal design and development activities since 1975 in central receiver and distributed receiver technologies. These activities have included design, fabrication, testing, and evaluation of several generations of components, subsystems, and systems for electric, process heat, and cogeneration applications.

The major obstacles to the utilization of solar energy are a) current high cost, b) performance verification, c) unproven system reliability and life, d) perceived technical and financial risk due to a lack of operational experience, and e) uncharacterized operations and maintenance costs. The major activities of the program focus on these issues as they relate to near and long-term bulk electric applications.

As a longer term thrust for the program, a limited amount of research and development is also under way to expand the breadth of applications including, for example, advanced systems for fuels and chemicals, and high-temperature process heat applications. Materials characterization, conceptual designs, systems analysis and assessment, and laboratory experimentation are being initiated in these higher temperature areas.

The Solar Thermal Technology Development Program is structured into 11 major R&D activity areas which fall under three broad catagories:

Collection Technology
Energy Conversion Technology
Systems and Application Technology

These 11 major R&D tasks are listed and defined in Table 2.1.

System-level planning targets expressed in terms of solar thermal capital cost, efficiency, and energy cost have been developed to meet the need for quantitative program goals. These are used to provide direction to research and development planning activities, to measure progress, to assess alternative technology options, and to make rational component research and development decisions. The system-level targets for solar thermal technologies as presented in the Five-Year Plan and 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. Although the goals are ambitious, achieving them would yield large returns in the form of a cost competitive and widely applicable source of renewable energy.

The long-term system targets in Table 2.2 are supported by a set of long-term component targets whose costs sum to the system costs and whose performance targets are consistent elements of the system performance targets. Table 2.3 shows this set of major solar thermal research tasks and their component targets. The long-term prospects for heat and electricity applications indicate the component targets for each research and development task in terms of annual efficiency and installed cost. To date, the efforts of industry and the federal government have lead to steadily decreasing energy costs from solar thermal systems. Continuing evolution of system components and designs will further decrease costs and increase the number of economically attractive applications. As the manufacturing rates for solar components gradually rise, production costs will decrease, contributing to further improvements in the economics of solar thermal energy.

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

Tasks	Definition
Collection Technology	
1. Optical Materials	Development of materials for the reflective surface 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 into thermal or chemical energy
Energy Conversion Technology	
4. Heat Engines	Development of components which convert thermal energy into electricity or shaft power via thermodynamic processes
5. Direct Conversion	Development of components that convert solar radiation into electricity or chemical energy without the use of a heat engine
6. Transport and Storage	Development of components which convey energy to the eventual consumption point or allow delay of its useage
Systems & Applications Technology	
7. Innovative Concepts and Applications	Entry point activities for promising component and system concepts which 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 from a system perspective
11. System Experiments	Activities related to the design construction, startup, operation, and testing of solar thermal installations

Table 2.2. Solar Thermal Technology Long-Term Targets

	Electricity	Heat
System Annual Efficiency	22-28%	56-68%
System Capital Cost (1984$)[a]	$1300-1600/kWe	$400-490/kWt
Capacity Factor	0.25-0.5	0.25-0.3
System Energy Cost (1984$)[b]	5¢/kWhe	$9/MBtu

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

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

Goals to be achieved within five years for each research and development task are described in Table 2.4. A five-year goal is needed to supply a focused orientation for each R&D activity. Five-year goals provide a logical progression for moving from the current capabilities to the long-term targets described in Tables 2.2 and 2.3. These goals represent expectations of attainable progress in each area, assuming continued funding at present levels.

Figure 2.1 graphically displays the component and system goals in the 5-Year Plan. Current capabilities and Long-Term Targets are plotted side-by-side to illustrate the magnitude of improvements needed. Thermal as well as electrical applications are included. The goals are quantified in a way that combines the cost and performance goals. The units are $/kWh/yr which are calculated by dividing the cost per unit area by the operating hours per year, the average insolation (the 5-Year Plan provides these assumptions also) and the efficiency. The result can be interpreted as the capital cost per unit of annual energy production capability.

Table 2.3 Current Technology Capabilities and Long-Term Targets

	Current Capabilities				Long-Term Targets			
	Electricity		Heat		Electricity		Heat[c]	
Research Tasks	Annual Efficiency	Cost (84$)	Annual Efficiency	Cost (84$)	Annual Efficiency	Cost (84$)	Annual Efficiency	Cost (84$)
1. Optical Materials ($/m²)	92%	20	92%	20	94%	10	94%	10
2. Concentrators[a] ($/m²)								
Central Receivers	55%	210	55%	210	64%	100	64%	100
Dishes	62%	650	62%	650	78%	140	78%	140
Troughs	—	—	44%	200	—	—	65%	110
3. Receivers[a] ($/m²)								
Central Receivers	90%	80	90%	80	90%	45	90%	45
Dishes	90%	350	90%	200	90%	70	95%	30
Troughs	—	—	75%	40	—	—	90%	30
4. Heat Engines ($/kWe)								
Central Receivers	35%	1000	n.a.	n.a.	39%	350	n.a.	n.a.
Dishes	33%	2900	n.a.	n.a.	41%	300	n.a.	n.a.
5. Direct Conversion	To be determined				To be determined			
6. Transport[a] ($/m²)								
Central Receivers	99%	75	99%	75	99%	25	99%	25
Dishes	99%	10	93%	110	99%	7	94%	65
Troughs	—	—	98%	40	—	—	98%	30
Storage ($/kWht)								
Central Receivers	98%	95	98%	95	98%	20	98%	20
Dishes	—	—	—	—	—	—	98%	20
Troughs	—	—	—	—	—	—	98%	20
7. Innovative Concepts and Applications	To be determined				To be determined			
8. Balance of Plant[a] ($/m²)								
Central Receivers	n.a.	70	n.a.	120	n.a.	50	n.a.	50
Dishes	n.a.	320	n.a.	120	n.a.	50	n.a.	50
Troughs	n.a.	—	n.a.	120	n.a.	—	n.a.	50
9. Central Receiver Systems ($/kWe or kWt peak)[d]	16%	4600	48%	1300	22%	1600[e]	56%	470
10. Distributed Receiver Systems ($/kWe or kWt peak)[d]								
Dishes	18%	8800	52%	1800	28%	1300[e]	68%	490[e]
Troughs	—	—	32%	790	—	—	56%	400[e]
11. System Experiments (¢/kWhe or $/MBtu)								
Central Receivers	16%	16¢	48%	29	22%	5¢[b]	56%	9[b]
Dishes	18%	37¢	52%	43	28%	5¢[b]	68%	9[b]
Troughs	—	—	32%	32	—	—	56%	9[b]

a Dollars per square meter of concentrator aperture

b System goals levelized in real dollars; values levelized in nominal dollars (assuming 7% inflation) are 11¢/kWhe, $14/MBtu. The $9/MBtu (84$) industrial process heat target is the levelized cost of delivered energy in the 1990's. It is derived from current fossil fuel costs of $5/MBtu (84$). See Appendix

c Includes production of fuels and chemicals.

d Normalized to turbine or process capable of handling peak field thermal output; includes indirect costs.

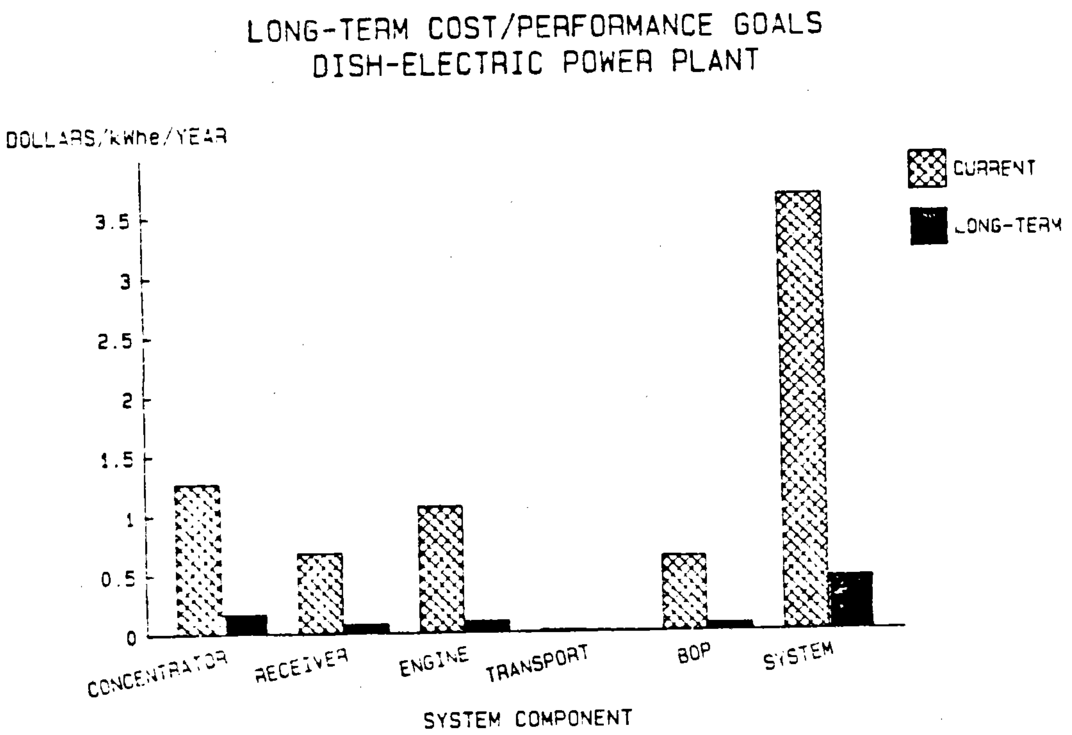
e Capacity factors are 0.5 central receiver electric, 0.26 dish electric, 0.29 central receiver thermal, 0.28 dish thermal, 0.24 trough thermal.

n.a — Not Applicable

Table 2.4. Research and Development Task Five Year Goals

Research Phase/Task	Five Year Goal*
Collection Technology	
1. Optical Materials	Develop polymer reflective materials with 93% lifetime averaged reflectivity, costing \$15/m², lasting 5 years
2. Concentrators	Improve annual efficiency by 5% and reduce cost to 120, 300, and 150 \$/m² for heliostats, dishes, and troughs, respectively.
3. Receivers	Design receivers for higher temperature applications while maintaining efficiencies. Reduce costs by 30% from the current capabilities.
Energy Conversion Technology	
4. Heat Engines	Reduce dish-mounted engine costs to \$1000/kWe(peak). Obtain 35% efficient (annually averaged) dish-mounted engines.
5. Direct Conversion Devices	Conduct exploratory research on promising high-flux/high-heat rate/photon-specific processes.
6. Transport and Storage	Obtain a 25 \$/kWht cost for storage while maintaining high efficiency. Transport costs reduced to 40, 75, and 30 \$/m² for central receivers, dishes, and troughs, respectively.
Systems and Applications Technology	
7. Innovative Concepts and Applications	Conduct research on novel concepts and applications Select the most promising for further study.
8. Balance of Plant	Characterize balance of plant requirements. Strive for automated control.
9. Central Receiver Systems	Study system integration issues through detailed designs. Achieve at least a 40% capital cost reduction while maintaining or improving efficiencies.
10. Distributed Receiver Systems	Study system integration issues through detailed designs. Obtain 5 percentage point efficiency improvements with at least a 40% capital cost reduction.
11. System Experiments	Obtain the necessary information to verify full system operating characteristics and identify technical requirements for further collection, conversion, and systems research. A 40% energy cost reduction will be sought

*Annual Efficiencies; \$/m2 of concentrator aperture area.



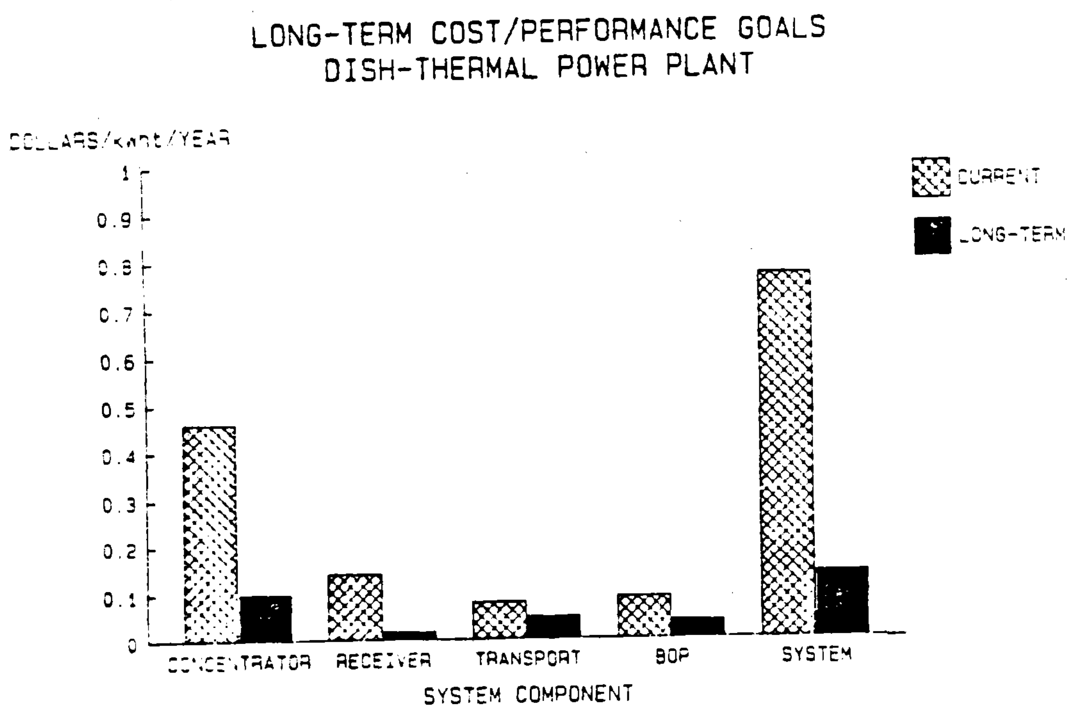


Figure 2.1. Long-Term Cost/Performance Goals

CHAPTER 3. DISTRIBUTED RECEIVER DEVELOPMENT PROJECT PLANS FOR FY85 AND FY86

SNLA's Solar Thermal Projects are organized into a technical Task and Subtask structure that is derived directly from the eleven R&D activity areas used in the overall Solar Thermal Program. This Task and Subtask structure is depicted in Table 3.1.

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 SNLA proposes to participate in FY85 and FY86 in nine of the eleven major tasks described in the Solar Thermal 5-Year Plan. This responsibility is reflected in the detailed plans given here, which cover development of collectors, receivers, and conversion technologies for Distributed Solar Thermal Systems.

The remainder of this chapter contains the detailed R&D plans for FY85 and FY86 for each task and subtask in the SNLA Distributed Receiver Development Projects. As these plans clearly indicate, the most critical R&D needs for this technology are the development of cost-effective and durable concentrators (under Task 2) and the adaptation and development of appropriate heat engine technology (under Task 4). Well over half of the project's resources are allocated to these areas. Distributed Receiver Systems, which includes System Engineering and Analysis and DRTF operations, Task 10, is assigned the next level of priority with respect to resource allocations. The remainder of the resources are utilized to investigate three important, relatively new areas of research, Receivers, Direct Conversion and Thermochemical Transport, and to continue support of Systems Experiments, Optical Materials development, and Balance of Plant development.

Table 3.1. The Task and Subtask Structure for SNLA's Distributed Receiver Development Project

Major Technology Areas		
Collectors	Energy Conversion	Systems and Applications
Tasks and Subtasks	Tasks and Subtasks	Tasks and Subtasks
1. Optical Materials	4. Heat Engines 4.1 Rankine Cycle 4.2 Stirling Cycle 4.3 Brayton Cycle 4.4 Alternative Engines	8. Balance of Plant
2. Concentrators 2.1 Line-focus Concentrators 2.2 Point-focus Concentrators	5. Direct Conversion	10. Distributed Receiver Systems 10.1 Systems Engineering and Analysis 10.2 Distributed Receiver Test Facility
3. Receivers	6. Transport and Storage	11. System Experiments 11.1 Small Community Solar Experiment 11.2 Solar Total Energy Project 11.3 Industrial Process Heat 11.4 MISR

TASK 1 -- OPTICAL MATERIALS

SERI has the primary responsibility for research on optical materials for solar thermal technology. However, Sandia conducts some work in this area to support other task elements, to support SERI's efforts and to utilize existing, unique capabilities.

STATUS AND PLANNED ACTIVITIES

Two general types of reflector materials have been established as feasible for solar thermal concentrators but both have limitations. Silvered glass has excellent specular reflectivity (~94%), but is heavy and has no tensile strength, so it is expensive to incorporate into collectors. Reflective films metallized with aluminum and bonded to sheet metal substrates are economical, but their specular reflectance is lower (~85%). The five-year program goals are to develop reflective polymer materials with 93% lifetime averaged reflectivity costing $\$15/m^2$ and with 5-year lifetimes. Both SERI and the 3M Company are conducting R&D on silver based polymer films which have the potential for meeting this goal. SNLA has been supporting these primary R&D activities by conducting environmental chamber cycling tests and periodic optical measurements on experimental films, and by evaluating the performance of collectors which utilize the new films. These activities, which take advantage of well-established test and measurement capabilities at SNLA, will be continued.

Another approach to the development of a more economical concentrator is to utilize silver deposited directly on a polished sheet metal substrate as a reflector. This approach requires a transparent coating to protect the silver from corrosion. An excellent candidate for such a coating is sol-gel, a glass-like material that is applied as a solution to a surface and then "dried" at a moderate temperature. SNLA has extensive research experience with this material, having investigated it as an AR-coating for parabolic trough receiver glazings and as an encapsulant for concentrator solar cells, as well as for numerous weapon component applications. Development of this sol-gel protected silver-on-sheet metal reflector concept will be continued at SNLA. At present, the first experimental samples have achieved 90% specular reflectivity after coating, but the coatings have not provided adequate corrosion inhibition. Work in FY85 will continue to emphasize development of a suitable sol-gel formulation for this particular application. Investigation of economical sheet metal polishing and silver deposition techniques will also be continued.

Note that the use of sol-gel for other solar thermal applications will continue to be investigated whenever apropriate. For example, if concentrator design analysis indicates that an aperture glazing would be advantageous for a particular receiver, the possibilities of using sol-gel AR coatings on the glazing, or fabricating the entire glazing with a multilayer sol-gel process will be considered.

SNLA will also provide general support to the optical materials research at SERI in the form of unique or comparative materials and optical measurements.

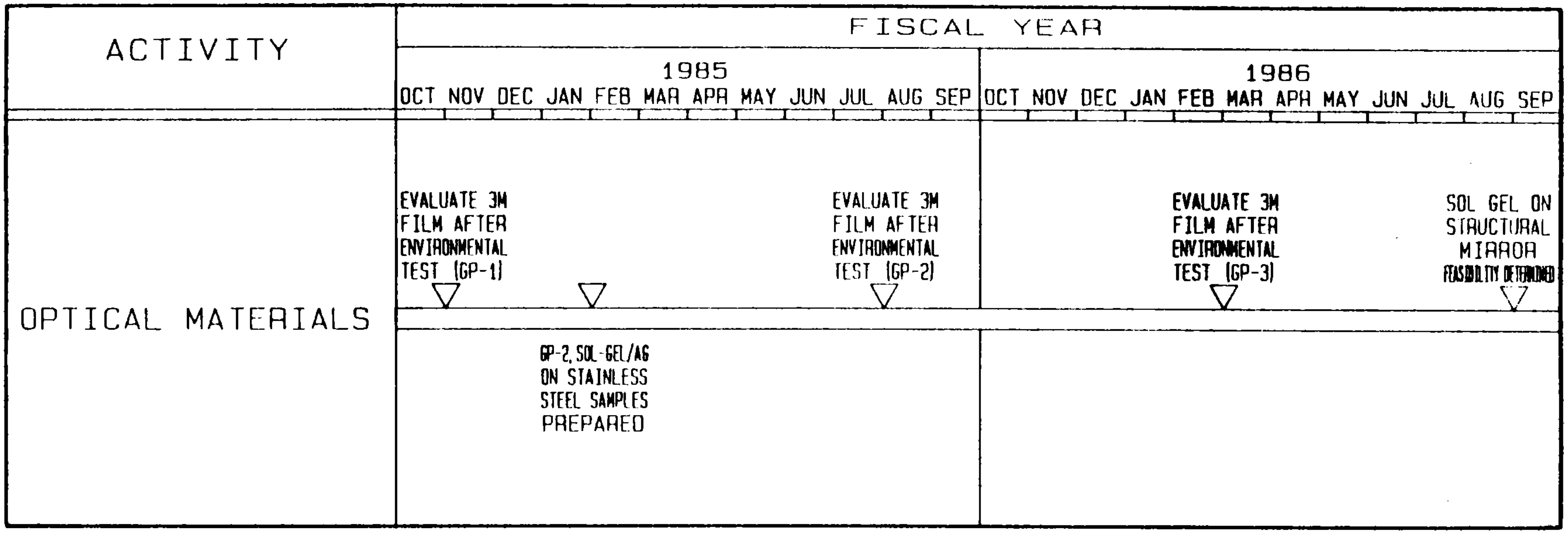
MAJOR PROCUREMENTS - Task 1.0

None.

RESOURCE REQUIREMENTS - Task 1.0

	FY85	FY86
In-house		
Manpower, MY	1.0	1.0
Costs, $K	140	140
Contracts, $K	-0-	-0-
Total Costs, $K	140	140

TASK 1 OPTICAL MATERIALS



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TASK 2 -- CONCENTRATORS

The concentrator is the unique and indispensible element of solar collectors which produce high level energy. The objective of the task is to develop concentrator designs for line-focus and point-focus solar collectors which are low in cost, perform with high efficiency, and have durability for long life with minimum maintenance and operational costs.

Concentrators for distributed receivers are divided into two subtasks: Line-focus and Point-focus. Development plans for heliostat concentrators are coordinated between SNLL and SNLA but are described and budgeted in SNLL's Central Receiver Development Plan.

Point-focus concentrator technology development represents one of the two primary needs for the success of dish electric technology. Thus, the plans described in Subtask 2.2 below represent a major and critical thrust of this 2-year plan.

Subtask 2.1 - Line-focus Concentrators

STATUS AND PLANNED ACTIVITIES

Current line-focus concentrator development has been limited to cost-shared, industry-developed flex hoses and rotary unions and silvered-reflectors being evaluated as MISR Project upgrades. The continuing evaluation of MISR systems has provided information on durability and maintenance on line-focus concentrators, including the upgrading of various concentrator components.

Line-focus concentrators must undergo further development in order to achieve the program goals of 65% efficiency at a cost of $110 per m^2 as stated in the Five-Year R&D Plan for Solar Thermal Technology. Although several collectors have achieved that efficiency, current costs are typically around $200 per m^2, and many systems have experienced inadequate reliability. Experience in this area has indicated that trough technology is still evolving fairly rapidly as industry and the various testing efforts continue to identify design changes with the potential for better performance, durability, reliability or costs.

The plan for continued development of line-focus concentrators is to conduct this work primarily in industry, so that resulting improvements can be readily incorporated into their commercial products. A Request for Proposals (RFP) was issued late in FY84 for line-focus collector development. It is expected that several contracts will be placed. The emphasis will be on the potential improvements in performance, cost, reliability, and durability of the proposed development efforts.

Release of an RFP of this type on an annual basis is anticipated for several years, assuming that worthwhile improvements continue to evolve and the need for federal support of this technology persists.

MAJOR PROCUREMENTS - Subtask 2.1

Active Contracts

None. Note that several small contracts for upgrade of MISR concentrator systems have been completed in the past year.

Anticipated Contracts

Title	Start Date	Funding, $K FY85	Funding, $K FY86
Line-focus Collector Development (Multiple Awards)	Jan 85	200	200

RESOURCE REQUIREMENTS - Subtask 2.1

	FY85	FY86
In-house		
Manpower, MY	1.0	1.0
Costs, $K	140	140
Contracts, $K	200	200
Total Costs, $K	340	340

Subtask 2.2 - Point-Focus Concentrators

STATUS AND PLANNED ACTIVITIES

Point-focus concentrator technology is considerably less mature than line-focus technology. Although some experimental parabolic dishes have demonstrated efficiencies close to the program goal of 78% for this technology, current costs are typically $500 to $1000 per m^2, well above the goal of $140, and there isn't nearly enough cumulative experience to evaluate reliability or durability. Thus, the critical need for this point-focus concentrator technology is to go through a developmental cycle wherein several teams design, fabricate, and test prototype concentrators. This cycle was initiated by the issuance of DOE's Innovative Concentrator Program Opportunity Notice (PON) in FY84. Contracts are imminent with three respondents. Sandia's role has been to assist with the technical evaluation of the proposals received. Sandia will also serve as Technical Manager for these contracts, and in that role will work very closely with the DOE and the contractor on their development efforts. The scope of these contracts includes analysis, design, fabrication, test and evaluation of dish or point-focus concentrators on the order of 12m diameter. The emphasis is on cost-effectiveness, durability and performance. Design considerations will include ease of manufacture, minimum material requirements, environmental resistance, assembly requirements, transportation, and field assembly and checkout. It is expected that these efforts will result in designs that can be manufactured and installed in moderate quantities for about $300 per m^2, which is the interim 5-year program goal.

The scope of this point-focus concentrator development will be broadened beyond these three DOE contracts in two ways. We plan to issue additional concentrator and component development contracts to proceed in parallel with the DOE efforts, and we are initiating an in-house point-focus concentrator design study. The contracts will permit the participation of additional, well-qualified concentrator R&D teams to participate in this critical developmental cycle. The in-house study will enable Sandia to develop appropriate concentrator design tools and the design tradeoff information to critically support and guide the contracted efforts. In addition, Sandia will pursue the in-house development of an alternate dish design provided that our design studies result in an alternative which has the potential of being superior to the those being pursued by industry.

Primary thrusts for the point-focus concentrator development effort will be weight and cost reduction, simplification of tracking and control systems, and minimization of labor in the fabrication and assembly processes from the manufacturing plant through transportation to site, field assembly and checkout. Alternatives such as die stamping, stretch forming, silvered film and silvered glass will be explored for applicability. Evaluation of reflective films will be continued. With the impending success of thin, lightweight, high-specularity, reflector materials, new design initiatives will be undertaken to assure that dish concepts which make maximum use of the weight and cost reductions allowed by these materials are ready when their capabilities are established.

In FY85, the primary additional point-focus concentrator development contract will be based on the Innovative Concentrator PON proposals. The funds in FY86 will likely be used both to support worthwhile follow-on efforts and to initiate a new concentrator development effort via an RFP which requires respondents to take advantage of the lessons learned during the FY85 development projects.

Our in-house design analyses will begin with development of better design modelling tools. Specifically, an integrated optical modeling capability for concentrator and receiver will be developed, as described in Task 3. This tool will allow performance studies to be conducted with reflector area, surface characteristics (reflectivity and specularity), concentration ratio, operating temperature, tracking and alignment accuracies, etc., as parameters. Coupling of this information with associated cost information and receiver and engine performance data will allow cost effectiveness comparisons. Both instantaneous (power versus cost) and integrated (annual energy versus cost) cost effectiveness comparisons of designs will be made.

An additional activity in this Subtask 2.2 is the Fixed Mirror Distributed Focus (FMDF) concept, which is being pursued by Texas Tech University under a prime contract from DOE/AL. The current activities include analytical work in the areas of structural analysis, cloud shading, dust erosion, controls, and performance; experimental work in the areas of wind loading, hail resistance, heat transfer fluid suitability, and ADVS (Crosybton system module) operation; and development work in the areas of mirror modules, superpanels, and receivers. 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. In the case of the FMDF project, it has been agreed that Texas Tech would operate more directly with AL and therefore management support in the "traditional" fashion is not being provided by SNLA. A relatively low manpower support level and no contract funds are required for this support activity.

MAJOR PROCUREMENTS - Subtask 2.2

Active Contracts

None.

Anticipated Contracts

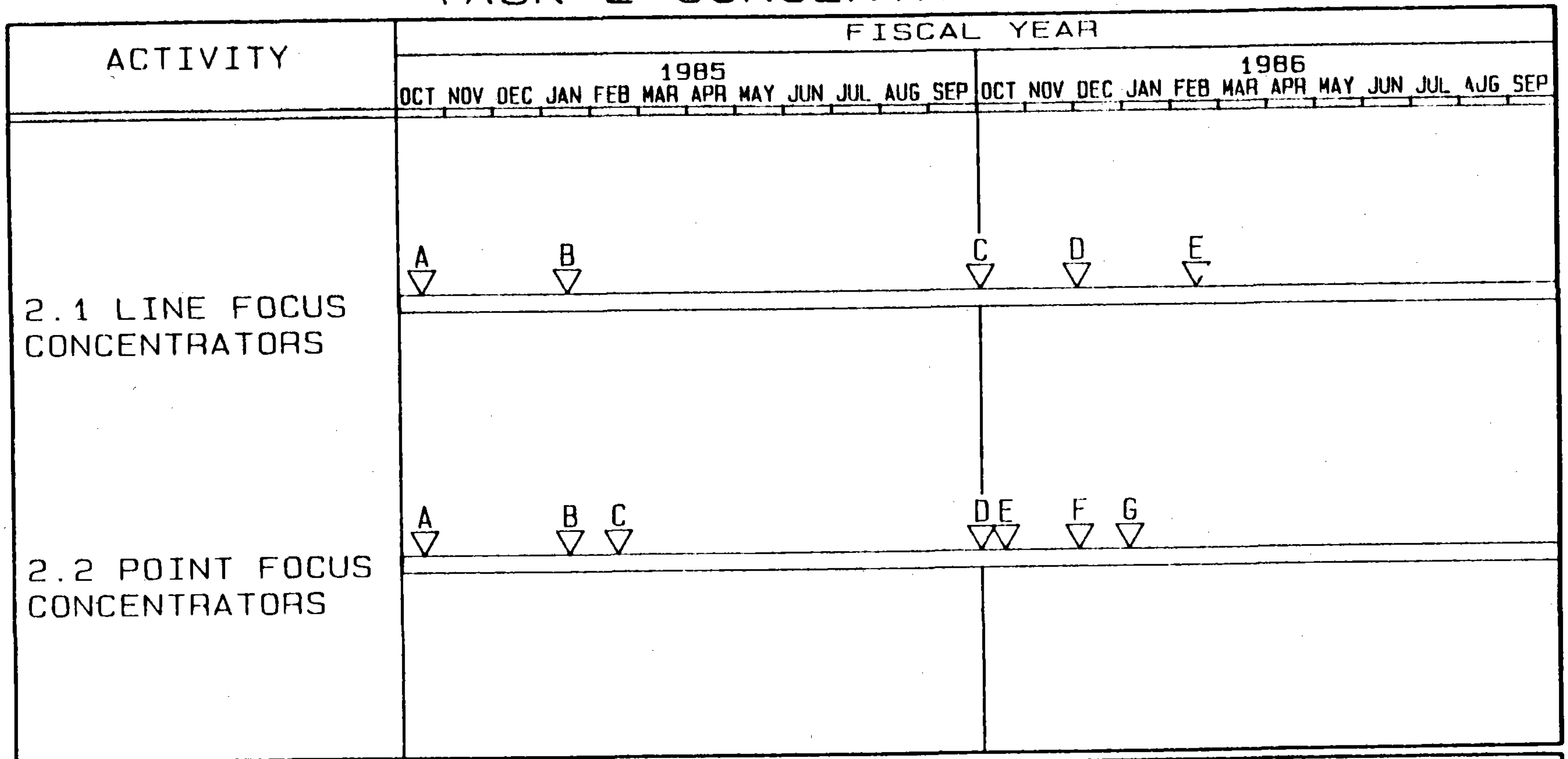
Title	Start Date	Funding, $K FY85	Funding, $K FY86
Innovative Concentrator Development (3 contracts through DOE/AL)	Jan 85	DOE/AL funding of $2000K total	
Additional Pt-focus Concentrator Development Contracts	Jan 85, Jan 86	700	2000

RESOURCE REQUIREMENTS - Subtask 2.2

	FY85	FY86
In-house		
Manpower, MY	4.5	4.5
Costs, $K	630	630
Contracts, $K	2700*	2010
Total Costs, $K	3330	2640

*Includes $2M DOE/AL funds

TASK 2 CONCENTRATORS



2.1 LINE FOCUS CONCENTRATORS:
- A= INITATE LINE FOCUS COMPONENT DEVELOPMENT
- B= PLACE LINE FOCUS COMPONENT DEVELOPMENT CONTRACTS
- C= ISSUE NEW COMPONENT DEVELOPMENT RFP
- D= LINE FOCUS COMPONENT FY85 CONTRACTS COMPLETE
- E= PLACE NEW COMPONENT DEVELOPMENT CONTRACTS

2.2 POINT FOCUS CONCENTRATORS:
- A= IN-HOUSE DISH DESIGN PROJECT INITIATED
- B= PLACE INNOVATIVE CONCENTRATOR PON CONTRACTS
- C= PLACE DISH DEVELOPMENT CONTRACT
- D= IC PHASE 1 COMPLETE PHASE 2 BEGINS WITH ACUREX
- E= IC PHASE 1 COMPLETE PHASE 2 BEGINS WITH ENTECH
- F= DDC PHASE 1 COMPLETE PHASE 2 BEGINS WITH SKI
- G= IC PHASE 1 COMPLETE PHASE 2 BEGINS WITH LAJET

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TASK 3 -- RECEIVERS

The receiver is a critical 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. Receiver design is, therefore, closely tied to the specific system and application for which it is built. In addition, the efficiency of the receiver is in series with other subsystems.

The long-term goal is to develop receivers with 90 to 95% efficiencies which can be manufactured for $30 per m^2 of concentrator aperture area (see 5-Year Plan). The objective of this task for FY85 and FY86 is 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.

STATUS AND PLANNED ACTIVITIES

A large number of receivers have been built for a variety of purposes in recent years. Applications range from relatively low-temperature process heat to high-temperature thermochemical conversion. Development of evacuated line-focus receiver tubes is being pursued at modest funding levels, both in-house and through contracts. Solar dish-electric receivers utilizing Brayton, Organic Rankine, Stirling and direct thermal-to-electrical conversion cycles are in various stages of development. (See Tasks 4 and 5)

The receiver represents a relatively small fraction of the system cost and has therefore not received the attention it deserves. Energy losses have subsequently been higher than expected. As it has become evident that improved receiver performance can be a cost effective way of improving system performance, more effort has been directed at identifying the various losses.

Our plans for the next two years are to

- o Develop analytical (computer modelling) tools for receiver design analysis;
- o Characterize the performance of existing receivers; and
- o Develop an understanding of receiver performance via modelling and receiver experimentation.

A receiver modeling capability will be established at SNLA. Computer codes developed by Ford for JPL will be made operational in the short term. More sophisticated programs such as those developed by GIT will be pursued. The models will integrate the concentrator with the receiver and thermal load. Emphasis will be on flexibility, ease of use and program transportability. Note that this work will make use of existing computer programs and experimental results whenever possible.

As data becomes available on existing receivers, it will be analyzed to develop an understanding of their performance. Moreover, as new concentrator receivers become available for testing, we will define and conduct measurements and thoroughly characterize their performance. In addition, experimental receivers will be fabricated and tested in order to supplement the above experimental data.

The result of these analytical and experimental efforts will be a thorough understanding of the design tradeoffs in receivers, which will permit the optimization of receiver designs for specific concentrator configurations and applications. This capability will also permit a more accurate projection of future costs and performances for receivers than is currently possible.

In FY86 these receiver development tools will be used to design and optimize a receiver to be integrated with an advanced heat engine. (See Task 4.)

Finally, experimental receiver/reactors for thermochemical transport will be designed, constructed, and tested during these 2 fiscal years. These efforts will be coordinated with those of Task 6.

MAJOR PROCUREMENTS - Task 3.0

Active Contracts

Contract No.	Title	Contractor	End Date	Funding, $K Prior FY	FY85	FY86
52-9909	Evacuated Tube Dev.	Acurex	Dec 84	63K	--	--

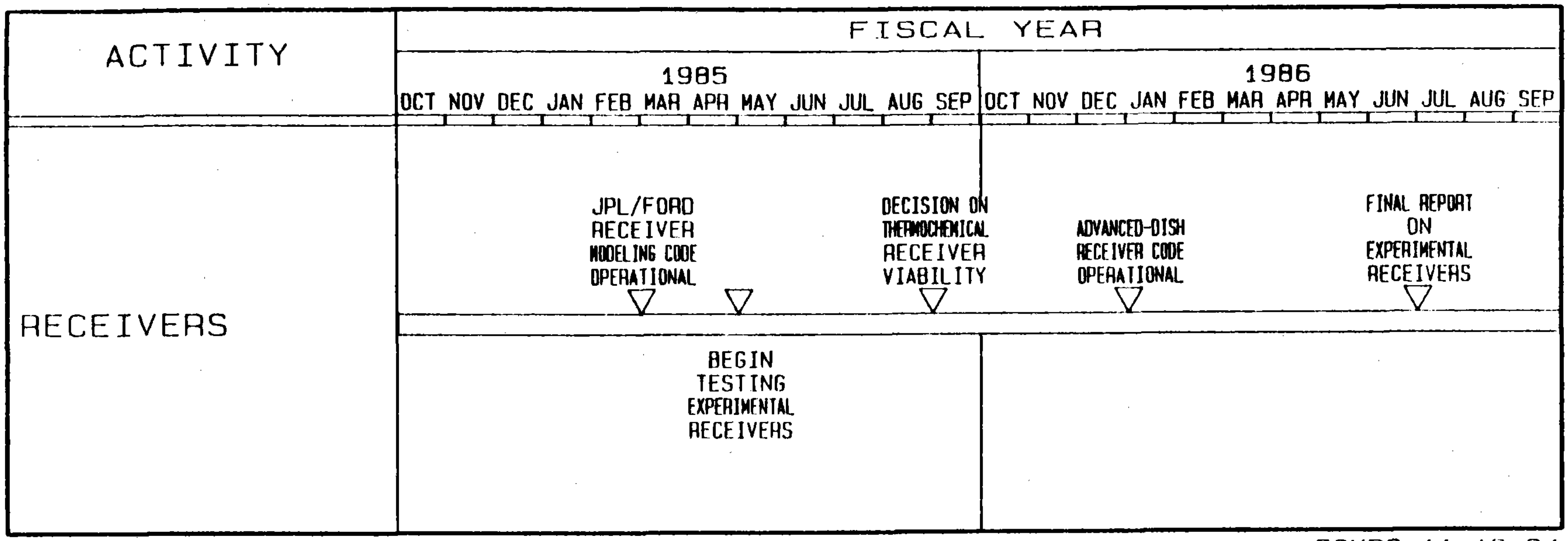
Anticipated Contracts

Title	Start Date	Funding, $K FY85	FY86
Thermochemical Receiver Development	Oct. 1984	--	150
Experimental Receivers	Jan. 1985	30	50
Dish-Receiver Computer Model Development	Mar. 1985	70	--
Optimized Receiver Development	May 1986	--	300

RESOURCE REQUIREMENTS - Task 3.0

	FY85	FY86
In-house		
Manpower, MY	2.0	2.0
Costs, $K	280	280
Contracts, $K	100	600
Total Costs, $K	380	880

TASK 3 RECEIVERS



RCVRS 11-13-84

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 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 in order to support the system-level goal of $.05/kWhe. The interim (5-year) goals are 35% and $1000/kWe. Alternate combinations of cost and performance which provide equivalent cost-effectiveness would, of course, be acceptable.

Task 4 has been organized into four subtasks. These are: Rankine, Stirling and Brayton cycles along with Advanced Development. The primary R&D activities in the past few years have involved the so-called 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 with prior year concepts which remain attractive continued and more recent opportunities such as the free piston Stirling and advanced or "exotic" cycles being studied for possible performance and economic improvements. Conceptual studies, designs, hardware development and testing will take place during FY85 and 86 through both in-house activities and contracts.

Subtask 4.1 - Rankine Cycle

STATUS AND PLANNED ACTIVITIES

B-N PROTOTYPE ORC -- The first generation Organic Rankine Cycle (ORC) engine development effort 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 technical transfer from JPL, Sandia contracted with Barber-Nichols for several hundred hours of hot bench testing and the addition of an automatic control system to the ORC. During FY85 this engine will be delivered to Sandia's Distributed Receiver Test Facility (DRTF) and integrated with the Test Bed Concentrator (TBC-1) for characterization.

ALTERNATE ORC -- In order to help determine the technical readiness and production cost of the ORC, procurement of another engine is planned. Utilizing design drawings from B-N, a cost-to-manufacture study will be conducted in the last half of FY85. If the cost studies are encouraging relative to the engine cost goals stated above, a competitive procurement would be initiated. Delivery and performance testing of this engine will be conducted at the DRTF in FY86.

Subtask 4.2 - Stirling Cycle

STATUS AND PLANNED ACTIVITIES

Stirling engine development to date has concentrated on the kinematic engine. One such engine, Model 4-95, was originally designed for automotive applications by United Stirling (USAB) of Sweden. However, under the DOE program a "solarized" version of the engine for dish-electric modules was evaluated. Under a cooperative agreement between DOE and the Advanco Corporation, this engine has been integrated with an 11-meter dish for a dish-Stirling system called Vanguard, which was put into operation at a test site in Rancho Mirage, CA, in mid-FY84. Because of its development status and performance, the kinematic engine has been accepted by the commercial market for solar dish-electric systems. In particular, McDonnell Douglas and United Stirling have teamed to develop and manufacture systems with capacities of 10 to 50 megawatts using 25 kW modules.

VANGUARD -- The Vanguard system, described above will be operated by Advanco in an experimental mode throughout FY85 under the terms of a contract with DOE/AL. The Southern California Edison Co. (SCE) and the Electric Power Research Institute (EPRI) have expressed considerable interest in the project and both organizations are monitoring progress and participating to the extent of suggesting tests or operating modes which would be of particular interest from their perspectives. As is the case for all contracted work from DOE/AL in the distributed receiver area, SNLA will provide technical and management support and active technical consultation as required. JPL will also be providing technical support to the Vanguard operations under a contract with SNLA. In addition to these activities, SNLA (probably with JPL as co-author) will prepare and distribute an evaluation report, similar to those for Shenandoah and the IPH projects, which provides program-level insights to the performance data and operating experiences from the Vanguard project.

ALTERNATE KINEMATIC -- The exclusive agreement between McDonnell Douglas and USAB, while a great vote of confidence to the dish-electric concept, leaves other solar developers without access to this very attractive kinematic Stirling engine. This is unfortunate for the Solar Thermal program because it delays the implementation of complete evaluation systems which are needed to provide test data and feedback to all elements of dish-electric systems -- not just the engines. Therefore, a search will be conducted for other sources of developed or close-to-being-developed kinematic Stirling engines. SNLA and JPL will cooperate in this search. Assuming a good candidate is found, a unit would be purchased, solarized, and delivered to the DRTF for testing.

HYBRID STIRLING -- The Gas Research Institute (GRI) has been negotiating with Advanco with regard to developing a gas/solar

HYBRID ORC -- A major activity in the Systems Analysis area will be studies of hybrid dish-electric systems. Assuming the concept looks attractive for the ORC a procurement would be initiated late in FY85 to design, build, and test a prototype hybrid engine -- first in the lab and then, with appropriate solarization, at the DRTF. Testing would be a FY86 activity. It may be possible to utilize the alternate engine referred to above for this purpose.

CENTRAL ORC -- Another Systems Analysis activity will be studies of larger ground-mounted ORC engines which are thermally connected to a field of parabolic dish solar collectors. (This departure from the one-dish-one-engine approach described above is the result of the encouraging results being developed in the Thermal Transport area.) The Heat Engine task will support this study by helping to identify available or easily modified ORC engines in the size range of interest to the analysts. Assuming the concept looks attractive, a procurement would be initiated in early FY86 to deliver and interface an appropriate engine for testing at the DRTF.

MAJOR PROCUREMENTS - Subtask 4.1

Active Contracts

Contract No.	Title	Contractor	End Date	Funding $K Prior FY	FY85	FY86
96-1797	ORC Engine	Barber-Nichols	FY85	68	45	--

Anticipated Contracts

Title	Start Date	Funding, $K FY85	FY86
Cost to Manufacture Study	Jan 1985	40	--
Alternale ORC Engine & Solarize	Jun 1985	300	--
Hybrid ORC	1st Q FY85	100	100
Central ORC	2nd Q FY86	--	200

RESOURCE REQUIREMENTS - Subtask 4.1

	FY85	FY86
In-house		
Manpower, MY	1.5	1.0
Cost, $K	210	140
Contracts, $K	620	300
Total Costs, $K	830	440

hybrid capability for the Vanguard module. The DOE has agreed to cooperate with GRI by co-funding such an effort, and funds were set aside in FY84 for this purpose. However, progress toward placing this contract has been slow under GRI. In view of the potential impact on the mid- and long-term economic goals which can be realized through the hybrid concept, (see rationale under Task 10, DR Systems) it would benefit the solar program to pursue this initiative with or without GRI in FY85. Discussions with GRI, USAB, Advanco, and DOE would preceed any decision on this matter.

FREE-PISTON STIRLING -- Another candidate for the Stirling cycle is the Free-Piston Stirling Engine (FPSE). This engine has the potential for high reliability, long life and high cycle efficiencies. FPSE is currently under development by several companies including Sunpower, Inc., and Mechanical Technology, Inc. (MTI). Both companies are developing FPSE auxiliary power units for the military. MTI, in addition, will be qualifying an engine for NASA/Lewis under the SP-100 program during FY85. A conceptual study will begin in FY85 assuming progress of the FPSE is encouraging. The next step would be a commitment to a prototype solarized FPSE in the 20 kW size range. This unit would be delivered for on-site testing at the DRTF during FY86.

MAJOR PROCUREMENTS - Subtask 4.2

Anticipated Contracts

Title	Start Date	Funding, $K FY85	FY86
Eval. of Vanguard Module Operation	Oct 1984	100	--
Kinematic Stirling (New Vendor)	Mar 1985	250	200
Stirling Hybrid Study	Sep 1985	100	--
Free-Piston Stirling Engine	Feb 1985	390	800

RESOURCE REQUIREMENTS - Subtask 4.2

	FY85	FY86
In-house		
Manpower, MY	2.0	2.5
Cost, $K	280	350
Contracts, $K	940	1050
Total Costs, $K	1220	1400

Subtask 4.3 - Brayton Cycle

STATUS AND PLANNED ACTIVITIES

SABC/SANDERS ASSOCIATES -- The first generation Brayton module was based on a Subatmospheric Brayton Cycle (SABC) engine. This engine was part of a Gas Research Institute (GRI) Heat Pump Program which was modified by Garrett AiResearch for solar application. During FY84 this engine was characterized by Sanders Associates, the Brayton module integration contractor, at their facilities using a LaJet stretched membrane concentrator. A Critical Design Review (CDR) based on Sanders results indicated that the SABC would not meet its performance goals. Further activity on the SABC was terminated, and a redirection to conduct a tradeoff study to be completed in early FY85 was agreed upon. Based on preliminary results of the in-house SNLA technology comparison study, dish-electric power plants based on the Brayton cycle may not be strong contenders to meet the mid- to long-term performance/economic goals of the Solar Thermal Five-Year Plan. An exception to this concern may be in hybrid systems, because the Brayton hardware is easy to adapt to the use of fossil fuels. For these reasons, no pressurized Brayton cycle hardware procurements are planned for FY85 and FY86 except for the SAGT described below. If subsequent information, such as the final results of the Sanders or SNLA studies, disclose that this judgment was erroneous, then mid-year budget adjustments from other engine development tasks will be needed to permit a more agressive approach.

SAGT -- An alternative Brayton engine is the Advanced Gas Turbine (AGT). The AGT-101 is being developed by the Garrett Turbine Engine Company (GTEC) for the DOE automotive program. This development is being managed for the DOE by NASA/LeRC. Ultimately, the automobile engine will use high-temperature ceramics to allow the turbine inlet temperature (TIT) to reach 2500°F. However, prior to this engine, scheduled for marketing in the early 1990's, are a metal and ceramic/metal engine operating at TIT's of 1600°F and 2100°F, respectively. If any Brayton-based dish electric system can meet the goals of the Solar Thermal Five-Year Plan, it should be one based on the AGT. The engine is being designed for low cost, very good fuel economy, and low maintenance -- the same attributes that are needed to meet the solar goals. The AGT is also attractive in that it is being developed in a well-funded program outside of the Solar Thermal program -- and by a group (NASA/LeRC) that is willing to cooperate with Solar Thermal. In prior years the Solar thermal program through JPL has secured a commitment from NASA to manage the fabrication of a 1600°F AGT to be delivered to the DOE for solarization and evaluation. Funds were transferred to NASA for this purpose. In parallel, a hot air receiver was designed, built, and tested by Sanders Associates for use with the 1600°F AGT. This assembly is referred to as the Solarized Automative Gas Turbine (SAGT). The SAGT will be delivered to SNLA and installed on a Test Bed Concentrator in mid-FY85. Additional funding of about $120K will be provided to GTEC and some local contractors to complete, deliver, install, and check out the SAGT. GTEC is progressing well in their development of the metal/ceramic 2100°F version of the AGT and NASA/LeRC feels that it would be sufficiently well developed to warrant solar testing by late FY86. The Sanders receiver would require only minor modification to be used with this engine -- in fact, the receiver has been tested to 2500°F. No funding has been provided NASA for this engine, and no commitment to buy one exists, but an estimate of $400K has been included in the Resource Requirements table in FY86 for this purpose.

MAJOR PROCUREMENTS - Subtask 4.3

Active Contracts

Contract No.	Title	Contractor	End Date	Funding, $K Prior FY	FY85	FY86
58-1001	Brayton Module	Sanders Associates	FY85	1129	180	--

Anticipated Contracts

Title	Start Date	Funding, $K FY85	FY86
Install 1600°F SAGT	Apr 1985	120	--
Fabricate and Install 2100°F SAGT	4th Q FY86	--	400

RESOURCE REQUIREMENTS - Subtask 4.3

	FY85	FY86
In-house		
Manpower, MY	1.0	1.0
Cost, $K	140	140
Contracts, $K	360	400
Total Costs, $K	500	540

Subtask 4.4 - Advanced Development

STATUS AND PLANNED ACTIVITIES

The heat engine represents the greatest technical challenge in the realization of the dish-electric concept in terms of meeting the mid- and long-term goals of the Solar Thermal Five-Year Plan (35% and $1000/kWe to 41% and $300/kWe). Therefore, over the next several years SNLA will conduct studies, including hardware development in certain cases, of current and long-term engine options to help determine which have the most potential, to provide focus and direction to development activities, and to reduce the breadth of development options being pursued and thereby enable more emphasis to be placed on the strongest candidates.

ENGINE ANALYSIS -- An engine technology comparison study was initiated in late FY84. As a fundamental element of this study, a code is being developed which combines and expands the capability of several existing codes. The new code will include performance and economic capabilities for SNLA's technical analyses. The study will produce absolute as well as comparative economic estimates and therefore it is expected to be a valuable tool in reducing the number of engine options in the Solar Thermal program to manageable and affordable quantities. The initial study will be complete in the second quarter of FY85, but a continuing effort in this area will be maintained to take advantage of new information which affects the initial assumptions.

ADVANCED ENGINES - Studies of advanced engine concepts will be followed by hardware phases in which SNLA will act as system integrator with development contractors involved in the design and fabrication of such engines which may survive the analytical screening process described above. Mid-term options could be liquid metal (Hg or Na) dynamic Rankine, high temperature steam Rankine, and combined cycles possibly utilizing thermochemical energy transport. The performance potential of such candidates equals, and can exceed significantly, the goals for engines in the Five-Year Plan. The issues would be development cost, production costs, and environmental and safety considerations -- the same issues which have inhibited widespread use of these concepts in the past.

MAJOR PROCUREMENTS - Subtask 4.4

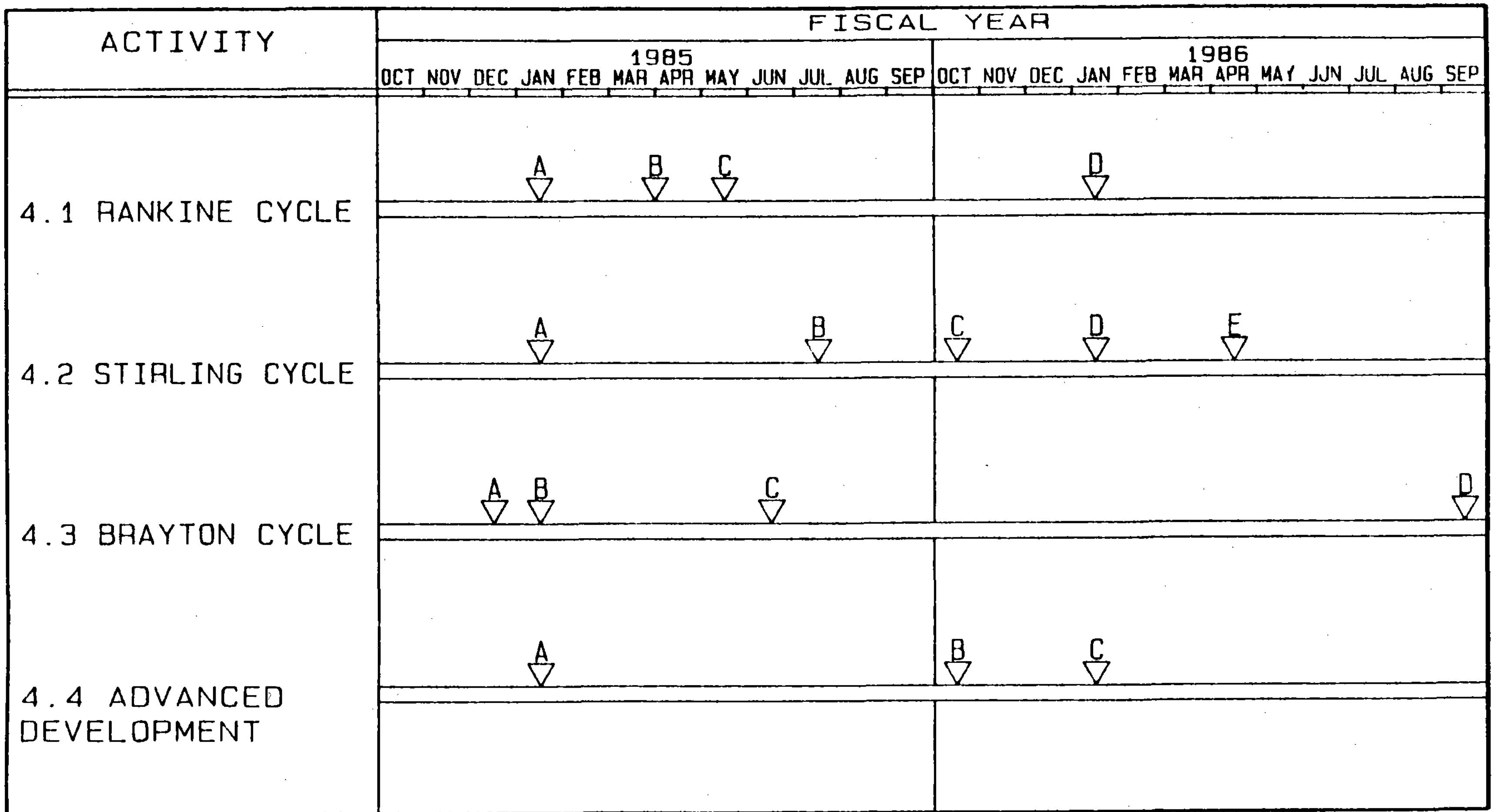
Anticipated Contracts

Title	Start Date	Funding, $K FY85	FY86
Advanced Engine Design	May 1985	125	50
Hardware Procurement	2nd Q FY86	--	300

RESOURCE REQUIREMENTS - Subtask 4.4

	FY85	FY86
In-House		
Manpower, MY	1.0	1.0
Cost, $K	140	140
Contracts, $K	175	400
Total $	315	540

TASK 4. HEAT ENGINE DEVELOPMENT



4.1 RANKINE CYCLE:
A= INITIATE B-N ORC TEST AT DRTF
B= COMPLETE COST TO MFG. ORC STUDY
C= COMPLETE INITIAL TEST B-N ORC
D= DELIVER ALTERNATE ORC

4.2 STIRLING CYCLE:
A= ISSUE REPORT ON STATE OF THE ART
B= PLACE FPSE CONTRACT
C= DELIVER KINEMATIC TO DRTF
D= PROTOTYPE HYBRID COMPLETED
E= DELIVER FPSE TO DRTF

4.3 BRAYTON CYCLE:
A= SANDERS TRADE STUDY COMPLETED
B= SABC FINAL REPORT PUBLISHED
C= SAGT 1600F DELIVERED TO DRTF
D= SAGT 2100F DELIVERED TO DRTF

4.4 ADVANCED DEVELOPMENT:
A= SNLA TECHNICAL COMPARISON COMPLETED
B= ADVANCED ENGINE FINAL DESIGN REVIEW
C= INITIATE ADV. ENGINE HARDWARE PROCUREMENT

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TASK 5 -- DIRECT CONVERSION

It is theoretically possible to achieve direct conversion of heat to electric energy at efficiencies of 25-35% using Liquid Metal Thermal Electric Convertors (LMTEC) which rely upon fast ion conductor materials and a pressure differential across this material. A LMTEC consists of a hot liquid metal ionizing at the surface of, and diffusing through, the fast ion conductor to a low pressure side where recombination with electrons traveling an external path takes place. The reduced metal vaporizes off the hot surface, condenses on a cooler surface, and flows to a reservoir from where it is electromagnetically pumped to the hot chamber to complete the cycle. Because this converter has essentially no moving parts, the possibility of reduced maintenance, higher reliability, and durability strongly suggests its use in power generation.

The objective of this Task is to engineer and develop promising direct conversion devices applicable to solar thermal systems. The engineering will concentrate on LMTEC devices, addressing different potential materials for the working element and the solid electrolyte or fast conductor, as well as associated temperature requirements and the resulting efficiencies. Development efforts will be directed toward scaling factors, energy cascading methods, power conditioning requirements, and solar matching aspects.

STATUS AND PLANNED ACTIVITIES

Investigators at Ford Motor Company have researched the Sodium Heat Engine (SHE), an Alkali Metal Thermal Electric Converter (AMTEC), for the past 20 years. They were issued a patent on the SHE in 1968. Their experimental results, reported in the literature, have confirmed their theoretical analyses using small laboratory-scale devices. Although their devices have not been specifically engineered to maximize conversion efficiencies, they have reported conversion efficiencies up to 19% thermal-to-electric. Researchers at JPL have addressed a key problem area in AMTEC, namely the significant degradation in the performance of the molybdenum electrode deposited on the low pressure side of the beta double prime alumina fast ion conductor. Finally, General Electric has reputedly built SHE models, but no reports on their work have been made available.

At the present time, there are two major R&D activities for the AMTEC. Under a DOE contract, Ford is investigating the electrode degradation problem, and is designing a 200W converter which is scheduled to be built in 1985. JPL is also continuing their electrode research under NASA funding for space power.

A primary need for LMTEC technology at this state is the initiation of engineering development. Sandia's plans in this task are to begin that development. Specifically, we shall

- o investigate alternatives to the use of sodium,
- o design, fabricate and test an experimental LMTEC, and
- o compare LMTEC technology with more conventional heat engine technologies and with MHD.

The reason for investigating other metals is that they offer such potential advantages as freeze protection, lower receiver temperature requirements, and a better match to parabolic dish technology. Use of another metal requires investigation of a new electrolyte, an activity which is already underway via a small contract to the University of Pennsylvania.

Our major activity over the next two years will consist of designing, fabricating, and testing an experimental LMTEC. Our efforts will emphasize maximizing conversion efficiency through better engineering design. Various configurations will be considered including cavity heated geometries which would couple well with solar receivers, and a multi-cell, parallel plate approach analogous to that used for fuel cells. In addition, we will begin to address such solar-design issues as variable orientation effects, cycling effects, number of cells, scaleability, and performance versus operating conditions. Note that in parallel with these development efforts, safety and environmental issues will be addressed, with particular emphasis on minimizing fire, electrical, and toxicity hazards.

It is important that new energy conversion technologies not be pursued without regard to their merits relative to other conversion technologies. Thus, we will analyze both LMTEC and MHD technologies relative to more conventional heat engine options for dish electric power. This work will be done as part of our Task 4 activities.

MAJOR PROCUREMENTS - Task 5.0

Active Contracts

None.

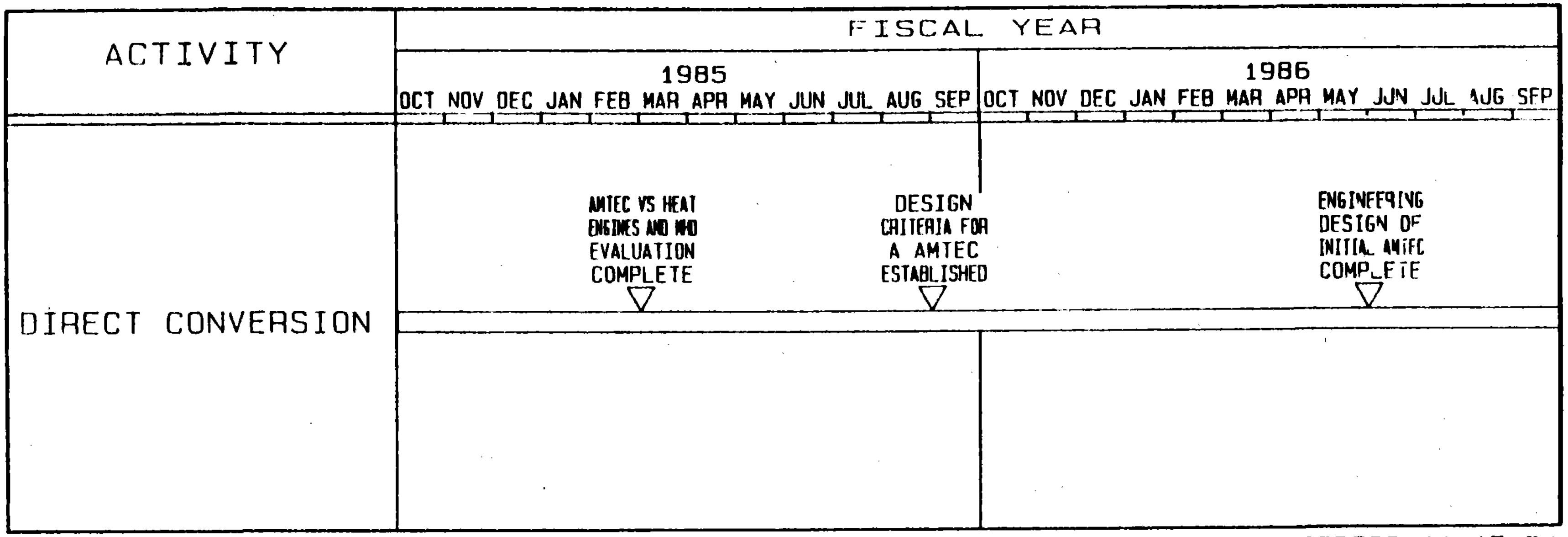
Anticipated Contracts

Title	Start Date	Funding, $K FY85	FY86
Component Development and Purchases	Nov 1984	50	100
Solid Electrolyte Work	Feb 1985	50	60
Engineering Development Support	Jan 1985	100	240

RESOURCE REQUIREMENTS - Task 5.0

	FY85	FY86
In-house		
Manpower, MY	2.0	2.5
Costs, $K	280	350
Contracts, $K	270	480
Total Costs, $K	550	830

TASK 5 DIRECT CONVERSION



DIRECTCO 11-15-84

TASK 6 -- TRANSPORT AND STORAGE

The efficient transport and storage of thermal energy is critical to the development of parabolic dish system technologies capable of supplying significant portions of the U.S. Industrial Process Heat (IPH) energy needs. 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.

Consistent with the mid- and long-term research and development goals for transport and storage set forth in the Solar Thermal Five-Year Plan*, the objectives of this task are to identify, develop, and evaluate high-efficiency, low-cost energy transport and storage systems suitable for high temperature solar thermal distributed receiver applications. A primary candidate for low thermal-loss energy delivery is the concept of thermochemical (TC) energy transport. Products from an endothermic reaction in the solar receiver/reactor are transported to the use point where they are recombined in an exothermic reaction (releasing energy to the user), and the "feedstock" produced is recycled back to the collectors. Counter-flow heat exchangers between the two streams at both ends of the loop allow transport at close to ambient temperatures, significantly reducing piping heat losses and costs.

STATUS & PLANNED ACTIVITIES

Activities to date have focused on investigating and evaluating potential TC energy transport systems. Milestones achieved during FY84 included:

1) Completion of a thermal transport technology review (including a review of the literature and conducting a workshop on TC transport).

2) Initiation of closed-loop proof-of-concept laboratory experiments for two TC systems:

   a. sulfur trioxide decomposition/recombination ($SO_3 \rightleftharpoons SO_2 + 1/2\ O_2$). These tests are being conducted at PSL/NMSU under contract to SNLA. To date more than 70 hours of closed-loop operation have been successfully completed without major problems.

*$75/m^2 to $65/m^2 and 94% efficiency for dish systems

b. carbon-dioxide reforming of methane ($CO_2 + CH_4 \rightleftharpoons 2CO + 2H_2$). This comprises the Closed-Loop Efficiency Analysis (CLEA) project being performed at SNLA. An elaborate, extensively instrumented experimental apparatus and data acquisition and handling system has been assembled and initial thermal testing completed.

3. Completion of a preliminary systems analysis comparing the performance and economics of the two candidate TC transport systems with various sensible (SEN) systems for select system sizes and a range of delivery temperatures.

Additional activities initiated during FY84 comprised mechanical, metallurgical and corrosion testing of candidate materials in SO_3, SO_2 and O_2 environments, and computer modelling of solar thermal distributed receiver transport systems for performance and cost evaluations.

Transport and storage efforts in FY85 and FY86 will continue and extend the experimental and systems analysis activities described above. Emphasis will remain on developing the technology of TC transport. The results of the preliminary performance/economics comparison of SEN and TC energy transport systems suggest two things:

1. TC transport appears more likely to meet the 5-Year Plan goals for dish transport systems, and

2. more realistic cost estimates of the critical components of TC transport systems (e.g., the endo- and exo-thermic reactor/heat-exchanger units) cannot be made until the technological and operating characteristics of the systems are better understood and the "real" problems (as opposed to the "potential" problems) addressed.

No work is anticipated in the area of energy storage as this is not considered to be as critical, in this time frame, to distributed receiver technology as is TC transport. This direction of effort is also consistent with current budget levels.

Laboratory closed loop experiments of the two TC transport systems during FY85 will complete the initial feasibility demonstration tests and proceed with second phase experiments designed to understand transient, control and scale phenomena. Supporting materials' experiments will be continued as needed.

The initial systems analysis comparing the performance and economics of sensible and thermochemical energy transport for distributed receiver systems will be documented. Further transport systems analysis activities in FY85 and 86 will focus on developing better computational tools for performing performance/economics evaluations of SEN and TC energy transport systems. Once these are operational, parametric systems sensitivity analyses, including performance/economics tradeoffs, will be performed for representative systems.

As soon as possible following completion of the closed loop laboratory experiments, materials support tests, and any systems parametric analyses performed in FY85, an assessment will be made of the future direction of TC energy transport as part of the Solar Thermal Technology Program. Assuming a favorable decision, a logical extension would be to proceed to closed loop TC transport testing at larger than laboratory scale and under more realistic conditions. Initial experiments would be conducted using conventional energy sources (electrical or combustion heating) for better control and repeatability. Based on the results of these tests and receiver experiments conducted under Task 3, one or more receiver/reactors would subsequently be configured for mounting on a parabolic concentrator(s) and manifolded into the transport loop. This will allow testing with combined conventional and solar energy sources and eventually with solar input alone.

In preparation for the above, a preliminary design of such a field-scale TC transport facility will be completed in FY85. A favorable decision concerning TC energy transport would initiate action to proceed first with a detailed design of the field-scale system, including site and support facilities, and second with the construction, installation, instrumentation, and checkout of the system and initiation of testing.

MAJOR PROCUREMENTS - Task 6.0

Active Contracts

Contract No.	Title	Contractor	End Date	Funding, $K Prior FY	FY85	FY86
47-7505	SO_3 Experiments	PSL/NMSU	10/31/84	75	175	100

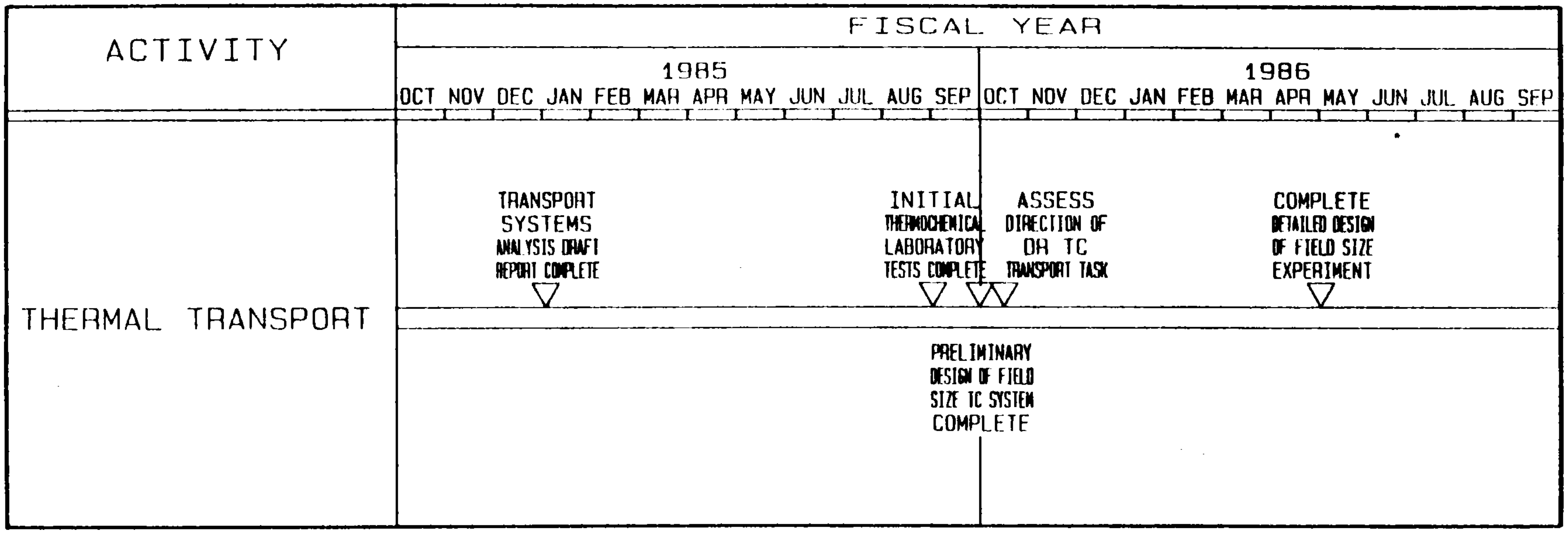
Anticipated Contracts

Title	Start Date	Funding, $K FY85	FY86
Materials Development	3/85	50	50
Field Scale TC Transport System:			
Design	11/85	--	50
Construction	3/86	--	100

RESOURCE REQUIREMENTS - Task 6.0

	FY85	FY86
In-house		
Manpower, MY	2.5	2.5
Costs, $K	350	350
Contracts, $K	250	325
Total Costs, $K	600	675

TASK 6 TRANSPORT AND STORAGE



TRANS 11-14-84

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 this Balance of Plant task for distributed receiver solar thermal systems is the development of economical and reliable control systems. It is clear that automated controls are necessary in order to keep systems operation costs at affordable levels. It is also clear that automatic system control is a realistic technical goal, because several systems, including the MISR parabolic trough systems and the Advanco Vanguard system, have successfully operated in an automatic mode for 2-week trial periods. Nonetheless, control system experiences in general have been somewhat disappointing, with failures being fairly common in the various system experiments. Moreover, many of the control systems to date incorporate outdated electronics technology and custom designs which tend to be expensive.

Higher developmental priorities for distributed receiver technology in FY85 preclude the possibility of undertaking a major control system development effort. Nonetheless, two important activities are planned. The first is a review of the control system requirement for a dish electric system in conjunction with a review of current electronics control technology, with the objective of developing a conceptual design of a complete control system that consists of commercially available components. The second is a review of the automated control system development efforts 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 FY86. This assessment will in turn be used to define the scope of an RFP for control systems development which will be issued in FY86.

MAJOR PROCUREMENTS - Task 8.0

None.

RESOURCE REQUIREMENTS - Task 8.0

	FY85	FY86
In house		
Manpower, MY	1.0	1.5
Costs, $K	140	210
Contracts, $K	0	80
Total Costs, $K	140	290

TASK 8. BALANCE OF PLANT

ACTIVITY	FISCAL YEAR 1985												FISCAL YEAR 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
CONTROLS									COMMERCIAL CONTROLS STUDY COMPLETE ▽									CONTROL SYSTEM DEVELOPMENT EFFORT INITIATED ▽					BALANCE OF PLANT DEVELOPMENT NEEDS ASSESSMENT COMPLETE ▽	

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TASK 10 -- DISTRIBUTED RECEIVER SYSTEMS

The objectives of this task in the Distributed Receiver Project are to perform the systems level engineering and analytical work needed to direct the developing component technologies. Such overview responsibility extends from the identification of industry application needs to technical design feasibility. Thus, the task defines the requirements or constraints on a system through trade-off studies and economics. These activities by in-house efforts and by outside contracts will provide conceptual designs of systems and subsystems. Additionally, the activities of this task provide for the operation and maintenance of the Distributed Receiver Test Facilities (DRTF).

Task 10 is organized into 2 subtasks:

10.1 Systems Engineering and Analysis
10.2 Distributed Receiver Test Facilities (DRTF)

Subtask 10.1 - Systems Engineering and Analysis

STATUS AND PLANNED ACTIVITIES

During FY 1984, a number of milestones in the Systems Engineering task were attained. Among these were the completion of a thermochemical piping performance economics analysis relative to a comparable size sensible heat thermal transport system, a performance and value analysis of the parabolic dish Cassegrainian (including the Richey-Chretien configuration) concentrator, the preliminary analysis of a minimum environmentally loaded parabolic dish concentrator, a study of the issues and possible solution to the flux "walkoff" problem, and the design and installation of a test facility to support the Distributed Receiver Development Project.

A number of existing computer modelling codes, installed to aid in these analyses, will provide tools for the future studies. Among these is the ETRANS code for distributed solar thermal systems analysis. As part of the Cassegrainian study, a concentrator optical analysis code (Concentrator Optical Performance Software) was installed at SNLA and is operational for parabolic dishes.

For FY85 a work plan has been structured to characterize systems component interactions in the context of systems delivering energy at various levels. Additionally, a closer look at previously identified subsystems including topics such as heat engine operating constraints, hybrid systems, and terminal concentrators is planned. In all cases, the efforts will emphasize increased performance and economical competitiveness.

New initiatives will be undertaken in support of the dish-electric and dish-thermal systems designs. The major dish system analytical and design efforts to be completed in the fiscal year are:

- o Dish-electric System Design Trade-offs
- o Centralized Steam Rankine Turbine System for Bulk Electric
- o 800°C Dish Thermal System for Industrial Processes
- o Cavity vs. External Receiver Trade-off Study
- o Hybrid Dish-Electric Study

A study to compare the performance and economics of the various dish-electric technologies will be expanded to include systems aspects. The code, as being developed under Task 4, is the concentrator, receiver, and distribution network performance would be included to proivide a useful comparison to the sesible and thermochemical distributed system performance studies. To enable comparison, the economic parameters of the dish electric systems will be consistent with those currently used for transport studies.

A study characterizing the conceptual design of a system which utilizes a central engine connected to a field of dishes is expected to be completed. The operating temperature is expected to be approximately 550°C. The potential for such a system arises from the combination of already defined penalties associated with long distance transport of sensible fluids and with engine positioning at the dish focal point. The study should define feasible energy production levels and lead to a follow-on preliminary design study.

In assessing both thermochemical and sensible transport systems, delivery of 800°C energy appears to be an excellent choice to examine system trade-offs. Due to the stresses of components operating in this regime, their relative performances and interaction should come to light. This activity should continue into FY86.

Studies completed in FY84 indicate that a hybrid (fuel and solar) operating mode can be very attractive from a system economics point of view. In near to mid-term applications the cost of energy production can be cut by factors of 2 to 4. In the long term a hybrid system could improve economics substantially (up to a factor of two) in non-ideal solar regions. Conceptual studies of hybrid dish-electric systems will be conducted both in-house and through contracts.

From an optics point of view a 90° rim angle concentrator and an external (spherical) receiver can be shown to be the optimum configuration for a dish (or a trough). The heat loss of the cavity receiver is less than that of an external one. However, a cavity receiver has a small acceptance angle and can only "see" a low rim-angle concentrator. Nevertheless, at some high operating temperatures, thermal losses will dominate over optical considerations and it becomes necessary to use a cavity receiver. This effort will quantify the temperature ranges in which each type of receiver/concentrator combination operates more efficiently.

In support of the receiver task (Task 3), the optical code (COPS) developed for the evaluation and design of the concentrators will be modified for use in the design and evaluation of thermal and engine receivers.

MAJOR PROCUREMENTS - Subtask 10.1

Active Contracts

Contract No.	Title	Contractor	End Date	Funding, $K Prior FY	FY85	FY86
59-4826	Terminal Conc.	Univ. of Chicago	FY85	65	0	0
25-7651	Technical Support	JPL	FY85	200	0	0

Anticipated Contracts

Title	Start Date	Funding, $K FY85	FY86
Small Central Engine System Study	FY85	150	240
815°C System Study	FY85	75	100
Hybrid Engine Study	FY85	50	0
External Receiver Study	FY85	50	0

RESOURCE REQUIREMENTS - Subtask 10.1

	FY85	FY86
In-house		
Manpower, MY	3.0	3.0
Costs, $K	420	420
Contracts, $K	325	405
Total Costs, $K	745	825

Subtask 10.2 - Distributed Receiver Test Facilities

STATUS AND PLANNED ACTIVITIES

The Distributed Receiver Test Facilities (DRTF) were activated and major progress was made in the establishment of this national test facility in FY 1984. The TBC's were moved from JPL's Parabolic Dish Test Side at Edwards Air Force Base to

Albuquerque. TBC-1 is installed and operational. These facilities will be used to test a number of concepts including the Solarized Automotive Gas Turbine and organic Rankine cycle engine modules. Preparations will be made for the installation and tests will be conducted of modules and concentrators resulting from the DOE/AL procurements for the Small Community Solar Experiments (SCSE) and the Innovative Concentrator Program Opportunity Notices.

Only those activities associated with establishing, operating and maintaining the DRTF are included here. Scheduling and budgeting for specific tests are included in the individual task activities.

MAJOR PROCUREMENTS - Subtask 10.2

Active Contracts

Contract No.	Title	Contractor	End Date	Funding, $K Prior FY	FY85	FY86
58-0206	TBC Move	Entech, Inc.		99	0	0
58-8316	DRTF Construction	Gardner-Zemke	FY85	275	0	0
58-3544	DRTF A&E Design	Black & Veatch	FY85	150	140	0

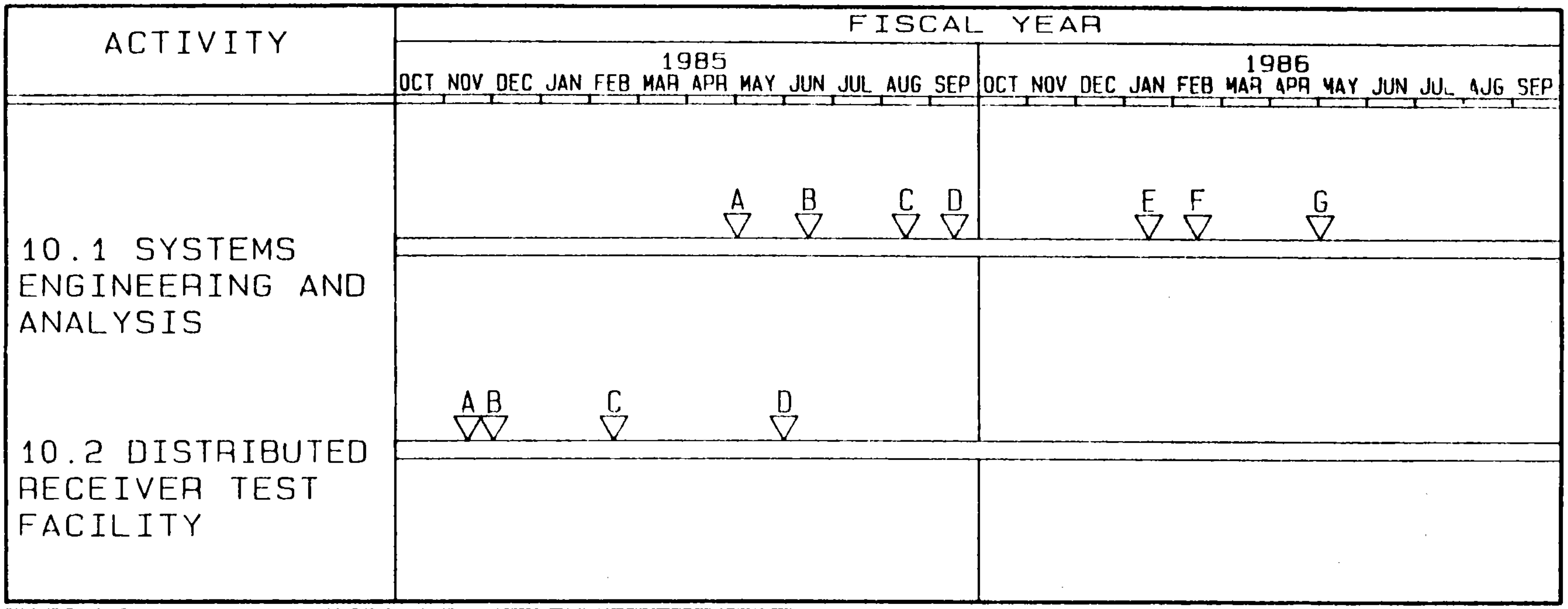
Anticipated Contracts

Title	Start Date	Funding, $K FY85	FY86
DRTF Construction	FY86	100	75

RESOURCE REQUIREMENTS - Subtask 10.2

	FY85	FY86
In-house		
Manpower, MY	2.5	3.0
Costs, $K	350	420
Contracts	160	75
Total Costs, $K	510	495

TASK 10. DISTRIBUTED RECEIVER SYSTEMS



10.1 SYSTEMS ENGINEERING AND ANALYSIS:
A= CONCENTRATOR CODE FOR RECEIVERS COMPLETE
B= DISH-ELECTRIC STUDY COMPLETE
C= CENTRAL ENGINE STUDY COMPLETE
D= TERMINAL CONCENTRATOR ANALYSIS COMPLETE
E= CAVITY VS EXTERNAL RECEIVER STUDY COMPLETE
F= 815 C DISH-THERMAL CONCEPT COMPLETE
G= HYBRID ENGINE STUDY COMPLETE

10.2 DISTRIBUTED RECEIVER TEST FACILITY:
A= TBC-1 OPERATIONAL
B= DISH-ELECTRIC FACILITY INSTALLATION COMPLETE
C= TBC-2 OPERATIONAL
D= TURNTABLE OPERATIONAL

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TASK 11 -- SYSTEM EXPERIMENTS

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

System experiments are being conducted for solar energy development projects in these four subtask areas:

11.1. Small Community Solar Experiments (SCSE)
11.2. Shenandoah Solar Total Energy Project (STEP)
11.3. Solar Industrial Process Heat (IPH)
11.4. Modular Industrial Solar Retrofit (MISR)

Subtask 11.1 - Small Community Solar Experiments

Two Small Community Solar Experiments are planned to evaluate 100 kWe solar electric plants in a small community utility environment. During FY1984, DOE/AL issued a Program Opportunity Notice (PON) seeking to award two cooperative agreements for 100 kWe electrical generating plants, one to be located at Osage City, KA, and the other on Molokai Island, Hawaii. Each plant is to consist of a number of modules. Barber-Nichols was selected as the prime contractor for the site at Osage City. The selection of a contractor and system for the Molokai experiment was deferred pending negotiation of a site agreement on Molokai and the resubmittal of proposals for Molokai consistent with the site selected by the DOE.

The Statement of Work for Osage City has been formalized, and the DOE has received a cost proposal for negotiation of the cooperative agreement. Discussions have been held with the Molokai Electric Company, but definitive arrangements have not been consummated for the site. Sandia contracts have been placed with the Hawaii Natural Energy Institute of the University of Hawaii to establish solar monitoring sites on Molokai and to operate and report on them until this responsibility can be assumed by the site participant.

STATUS AND PLANNED ACTIVITIES

Plans for the next two years are to continue the efforts in technical support of the DOE/AL in performance of the Small Community Solar Experiments.

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 plan for SCSE 2 on Molokai is dependent on the negotiation of the cooperative agreement for the site and the reissue of the PON by DOE/AL.

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 qualification test modules. Close day-to-day contact will be maintained with the responsible contractors.

MAJOR PROCUREMENTS - Subtask 11.1

Active Contracts

Contract No.	Title	Contractor	End Date	Funding, $K Prior FY	FY85	FY86
58-5912	Monitoring Stations on Molokai	U of Hawaii	Mar 1985	15	--	--

Anticipated Contracts

Title	Start Date	Funding, $K FY85	FY86
Operate Molokai Monitoring Stations	Jan 1985	25	25
SCSE 1 Test Site Preparation (DRTF)	Mar 1985	90	--
Molokai Site Participant Cooperative Agreement	Jan 1985	DOE/AL funding of $200K total	

RESOURCE REQUIREMENTS - Subtask 11.1

	FY85	FY86
In-house		
Manpower, MY	3.0	3.0
Cost, $K	420	420
Contracts, $K	315	185
Total Cost, $K	735	605

Subtask 11.2 - Shenandoah Solar Total Energy Project

The Solar Total Energy Project, located at Shenandoah, GA, uses the cogeneration concept to produce electricity, steam for operating textile presses, and chilled water for air conditioning. The system employs 114 parabolic dish collectors that develop 400°C temperatures in a silicone heat transfer fluid. Currently a set of 29 tests is being conducted by Georgia Power Co. under a cooperative agreement with DOE. Eleven of the tests have been completed. The tests are scheduled for completion by December 1984. Evaluation of test results by Sandia personnel is scheduled for completion by December 1985.

STATUS AND PLANNED ACTIVITIES

The cooperative agreement with Georgia Power for operation of the Shenandoah Total Energy Project will expire in FY1985 upon completion of the current test program. Sandia will evaluate the results of the tests and will document and report their evaluation. Subsequent to the expiration of the cooperative agreement, Sandia will monitor operation of the Shenandoah project and will provide technical support as necessary.

MAJOR PROCUREMENTS - Subtask 11.2

Active Contracts

Contract No.	Title	Contractor	End Date	Funding, $K Prior FY	FY85	FY86
47-7666	Shenandoah & IPH Studies	Cal Poly	Dec 1984	50	--	
59-5022	Shenandoah	SERI	Mar 1985	98	--	-

Anticipated Contracts

None.

RESOURCE REQUIREMENTS - Subtask 11.2

	FY85	FY86
In-house		
Manpower, MY	1.0	1.0
Costs, $K	140	140
Contracts, $K	0	0
Total Costs, $K	140	140

Subtask 11.3 - Industrial Process Heat

The Industrial Process Heat Project consists of seventeen solar energy experiments located at industrial sites throughout the country. In the experiments solar energy is used to produce hot water or steam for various industrial processes such as drying agricultural products and producing chemicals. The experiments are conducted in three phases: design, construction, and operation. When the experiments are complete the solar energy systems are transferred to the owners of the sites. At the beginning of FY85 two of the experiments will be in the final stages of the operational phase. The rest of the experiments will have been completed. The solar energy systems for ten of the completed experiments are active under owner operation. Five systems are no longer operating.

STATUS AND PLANNED ACTIVITIES

The DOE phase of the IPH project will be completed when the final experiment is finished in May 1985. Subsequently, 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 bi-monthly and annually. Technical consultation and assistance will be provided as required (within reason).

MAJOR PROCUREMENTS - Substask 11.3

Active Contracts

Contract No.	Title	Contractor	End Date	Funding, $K Prior FY	FY85	FY86
50-2567	Tech. Support Services	Tech Reps	Sep 1985	150	--	--
47-1385	Services (IPH)	ETEC	Sep 1984	200	--	--

Anticipated Contracts

Title	Start Date	Funding, $K FY85	FY86
ETEC Services	Oct 1984	70	--
Cal Poly Services	Jan 1985	50	--

RESOURCE REQUIREMENTS - Subtask 11.3

	FY85	FY86
In-house		
Manpower, MY	0.9	0.5
Cost, $K	125	70
Contracts, $K	120	0
Total Cost, $K	245	70

Subtask 11.4 - Modular Industrial Solar Retrofit

Solar energy systems for producing low-temperature process heat were developed and evaluated in the Modular Industrial Solar Retrofit program. Five test modules were designed, fabricated, and installed for performance testing. Primary tests have been completed and reports are in process. The systems are currently being used to test hardware modifications and industry-developed components and subsystems.

STATUS AND PLANNED ACTIVITIES

The MISR project will be completed, and reports of the qualification testing will be issued in FY85. Tests to be completed in FY85 include evaluation of evacuated receivers and life cycling of components installed in previous years. The systems will remain in place at Sandia to support future development and test programs for line-focus technology.

MAJOR PROCUREMENTS - Subtask 11.4

Active Contracts

Contract No.	Title	Contractor	End Date	Funding, $K Prior FY	FY85	FY86
47-5890	Solar Collectors	SKI	Sep 1984	51	--	--
52-5653	Solar Tech. Support	EG&G	Sep 1984	135	115	--
52-9909	Evacuated Receiver	Acurex	Sep 1984	63	--	--
96-9329	Sagged Glass Collectors	Acurex	Sep 1984	66	--	--

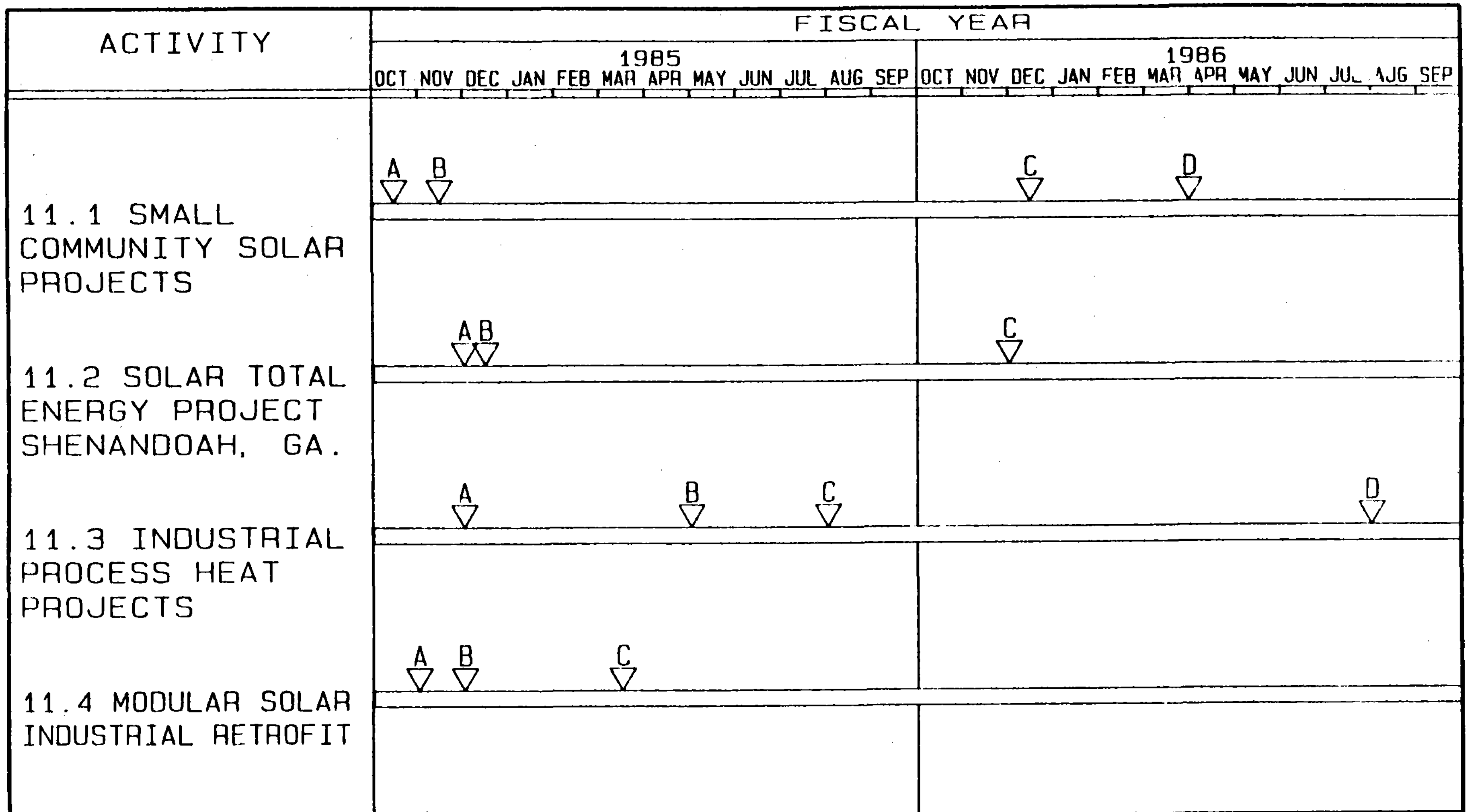
Anticipated Contracts

None.

RESOURCE REQUIREMENTS - Subtask 11.4

	FY85	FY86
In-house		
Manpower, MY	0.1	0
Costs, $K	15	0
Contracts, $K	115	0
Total Costs, $K	130	0

TASK 11. SYSTEM EXPERIMENTS



11.1 SMALL COMMUNITY SOLAR PROJECTS:
- A= ISSUE REVISED PON FOR MOLOKAI SCSE (DOE)
- B= PLACE CONTRACT FOR SCSE-1 (DOE)
- C= COMPLETE FAB. OF SCSE-1 TEST MODULE
- D= COMPLETE TESTS OF SCSE-1 MODULE

11.2 SOLAR TOTAL ENERGY PROJECT SHENANDOAH, GA.:
- A= COMPLETE EVALUATION TESTS
- B= TRANSFER OWNERSHIP TO GEORGIA POWER
- C= COMPLETE DOE EVALUATION

11.3 INDUSTRIAL PROCESS HEAT PROJECTS:
- A= COMPLETE CATERPILLAR EXPERIMENT
- B= COMPLETE LONE STAR BREWERY EXPERIMENT
- C= ISSUE FY84 IPH EVALUATION REPORT
- D= ISSUE FY85 IPH EVALUATION REPORT

11.4 MODULAR SOLAR INDUSTRIAL RETROFIT:
- A= COMPLETE EVACUATED RECEIVER TEST
- B= COMPLETE MISR EVALUATION REPORT DRAFT
- C= PUBLISH MISR EVALUATION REPORT

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CHAPTER 4. RESOURCES AND IMPLEMENTATION

This chapter provides summary information for the FY85 and FY86 plans for SNLA's Solar Thermal Projects in several formats. These include:

- Major Milestone Charts
- Resource Requirements Summary Table
- Capital Equipment
- Management Plan
- Procurement Plan
- Project Organization and Key Personnel
- Relation of FY84 and FY85 Task Structures

MAJOR MILESTONES FOR FY85 AND FY86

The most important milestones and deliverables from the task and subtask plans of Chapter 3 have been assembled onto the Major Milestone Chart in Figures 4.1a and 4.1b. The overall selection of these major milestones reflects both the focus of our projects on the most critical R&D needs for distributed receiver technology and the importance of achieving these milestones in order to realize the overall 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. Note again that the resource allocations follow our emphasis within the Project on the primary concentrator and engine R&D needs while still maintaining a reasonable balance of all aspects of distributed receiver solar thermal technology development within the overall budget constraints.

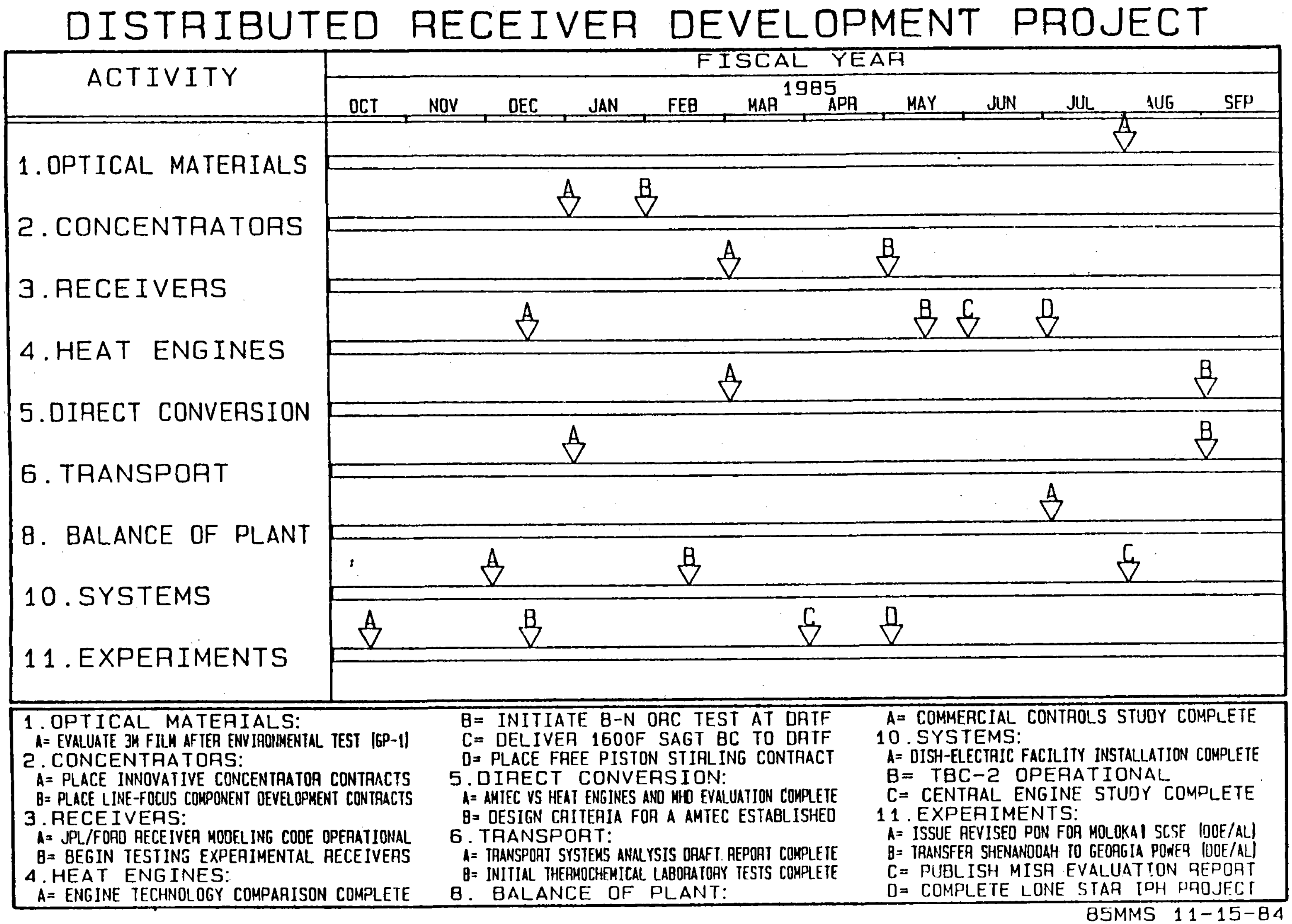
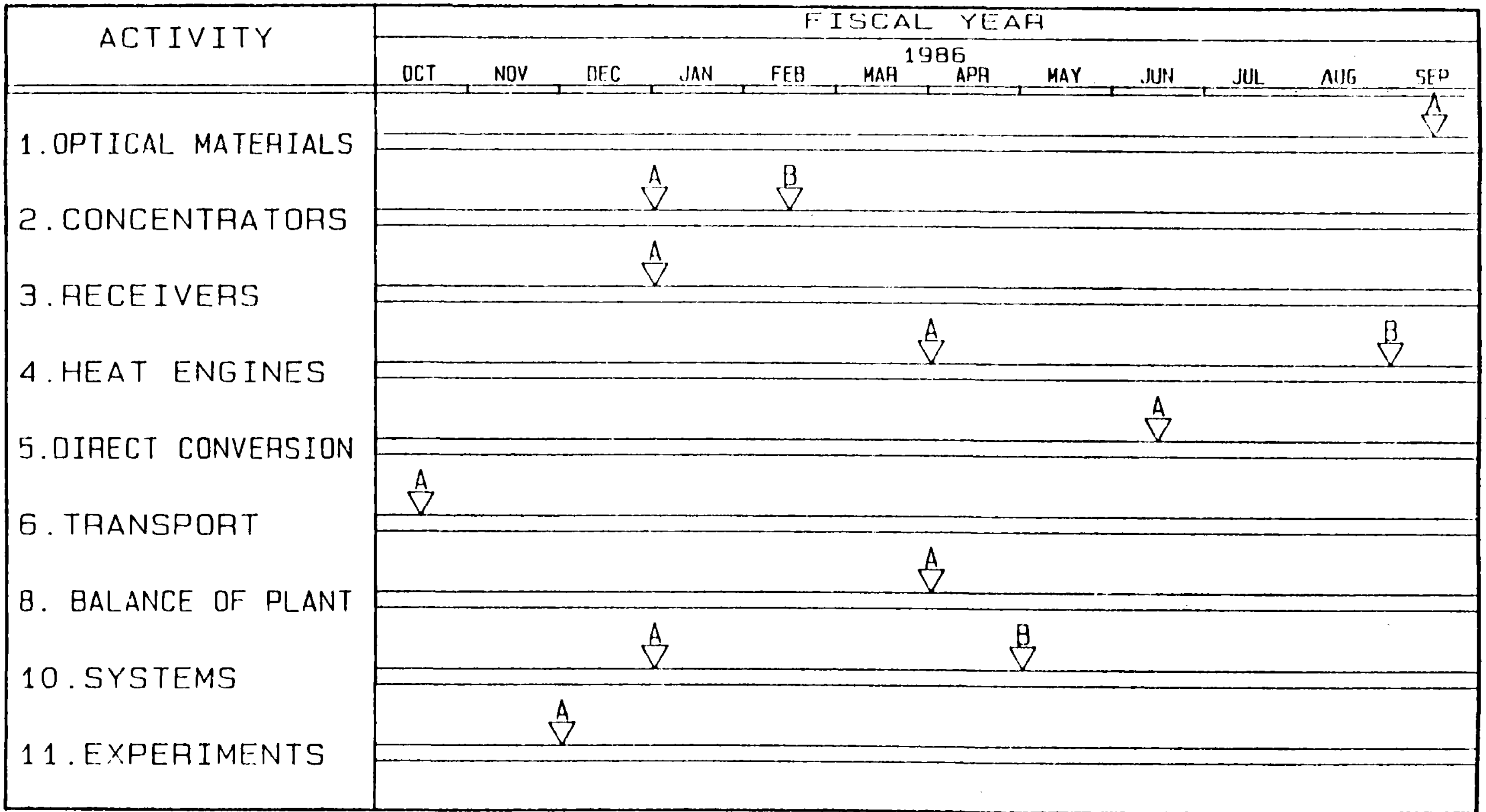


Figure 4.1a. Major Milestones for FY85

DISTRIBUTED RECEIVER DEVELOPMENT PROJECT



1. OPTICAL MATERIALS:
   A= SOL-GEL ON STRUCTURAL MIRROR FEASIBILITY DEFINED
2. CONCENTRATORS:
   A= BEGIN DISH CONCENTRATOR DEVELOPMENT PHASE 2
   B= PLACE NEW LINE-FOCUS COMPONENT CONTRACTS
3. RECEIVERS:
   A= ADVANCED DISH RECEIVER CODE OPERATIONAL
4. HEAT ENGINES:
   A= DELIVER FREE PISTON STIRLING TO DRTF
   B= DELIVER 2100F SAGT BC TO DRTF
5. DIRECT CONVERSION:
   A= ENGINEERING DESIGN OF INITIAL AMTEC COMPLETE
6. TRANSPORT:
   A= ASSESS DIRECTION OF TC TRANSPORT TASK
8. BALANCE OF PLANT:
   A= CONTROL SYSTEM DEVELOPMENT INITIATED
10. SYSTEMS:
   A= CAVITY VS. EXTERNAL RECEIVER STUDY COMPLETE
   B= HYBRID ENGINE STUDY COMPLETE
11. EXPERIMENTS:
   A= COMPLETE FABRICATION OF SCSE-1 TEST MODULE (DOE/AL)

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Figure 4.1b. Major Milestones for FY86

Table 4.1. Resource Requirements Summary

DISTRIBUTED RECEIVER DEVELOPMENT PROJECT -- FY85 and FY86

	FY85				FY86			
	In-House		Contracts	Total	In-House		Contracts	Total
	MY*	$K	$K**	$K	MY	$K	$K	$K
<u>Collection Technology</u>								
1. Optical Materials	1.0	140	0	140	1.0	140	0	140
2. Concentrators**	5.5	770	2900	3670	5.5	770	2210	2980
3. Receivers	2.0	280	100	380	2.0	280	600	880
<u>Energy Conversion Technology</u>								
4. Heat Engines	5.5	770	2095	2865	5.5	770	2150	2920
5. Direct Conversion Technology	2.0	280	270	550	2.5	350	480	830
6. Transport and Storage	2.5	350	250	600	2.5	350	325	675
<u>Systems and Applications Technology</u>								
8. Balance of Plant	1.0	140	0	140	1.5	210	80	290
10. Distributed Receiver Systems	5.5	770	485	1255	6.0	840	480	1320
11. Systems Experiments**	5.0	700	550	1250	4.5	630	185	815
Totals	30.0	4200	6650	10850	31.0	4340	6510	10850
Capital Equipment				150				150

*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 stock room withdrawals.

**Includes: Task 2.2 Concentrators -- $2000K DOE/AL Funding
Task 11.1 Small Community Experiments -- $200K DOE/AL Funding

CAPITAL EQUIPMENT

Capital equipment will be needed to support distributed receiver research and development and to support operation and planned capability expansion of the DRTF. Equipment needed to support R&D in the Distributed Receiver Development Project includes such items as control and data acquisition equipment for the DRTF and several other tasks, optical measurement equipment, materials handling equipment, switchgear for the DRTF, engine testing diagnostic equipment, hazardous and toxic materials laboratory equipment, metallographic testing equipment, and materials corrosions testing equipment. A capital equipment budget of $150K is being requested for commitment in FY85, but this may prove to be a very tight budget area.

MANAGEMENT PLAN

Management encompasses project planning, coordination, control, reporting, and programmatic support. Although technology transfer is a consequence of R&D activities within all of the tasks described earlier, it is a very important and direct result of the project reporting conducted under project management. A second role of project management is to provide appropriate plans and organization for SNLA's Solar Thermal Projects and to ensure that they are properly focussed and coordinated with respect to the National Solar Thermal Technology Program.

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. Appropriately, project management also supports other specialized planning requirements, such as needs for international plans or concentrator R&D plans.

Project reporting is conducted at several levels. Within the federal Solar Thermal Technology Program community, weekly and bi-monthly reports are prepared, and oral reviews are conducted on a quarterly basis. In addition, material on Distributed Receiver Technology Development is prepared for the Solar Thermal Technology Annual Evaluation Report. Finally, numerous professional society conference presentations, topical reports and public information types of materials are prepared on a continuing basis.

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.

A major project reporting and technology transfer activity planned for FY85 and FY86 is to conduct annual Distributed Receiver Technology Conferences, scheduled for April or May of each year.

Project coordination is extremely important in the current environment of limited R&D funds because it can identify ways of increasing the payoff of specific R&D activities to broader program areas. Coordination is not only emphasized within the DOE Solar Thermal Program, but it has also proven useful, for example, between such diverse areas as the thermochemical transport research and coal gasification research, both of which utilize catalytic reactions.

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. Each subtask contains a list of anticipated contracts for FY85 and FY86. In addition, the procurement summary listed in Table 4.2 provides a condensed list of those major new procurements which are anticipated in FY85.

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 the 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 to be returned unopened with instructions regarding the proper route of submittal to DOE Headquarters. Once such a proposal is submitted through the proper channels, reviewed, and accepted for funding by the appropriate Division Director (DOE Headquarters), SNLA can place the contract as a result of a written request from that Director. The strategy then is to expect to hold the contracts for any approved unsolicited proposals on distributed receiver system activities. These will be funded by SNLA either on existing funds or, if such funds are not available, on funds to be forwarded to SNLA through ALO's financial plan accompanying the request to place the contract. In implementing this strategy, 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 AOP 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. While goals are established and careful efforts are made to meet them, meeting the goals is to be done in a manner consistent with meeting the technical programmatic objectives, and thus the former is not the primary objective. Every effort will be made by Sandia to meet the goals set by the Solar Thermal Technology Division for small and minority businesses. Sandia policy for procurements does not permit the use of set-asides in the manner that the FPR's suggest for a federal acency. It does, however, permit accomplishment of the objectives by the use of a limited bidders' list. As a result, we believe it is possible to meet the STT goals for procurement from small and minority businesses. It is our preference to incorporate as much of this small and minority business activity in the major or mainstream procurements as possible.

Table 4.2. Procurements Summary Table

FY85 Major Anticipated Contracts

Title	Task	Start Date	FY85 Funding, $K
Line-Focus Concentrator	2.1	1/85	200
Innovative Concentrator Development (3 Contracts)	2.2	11/84-1/85	2000
Additional Point-Focus	2.2	12/84	700
Dish Receiver Computer Model	3.0	3/85	100
Alternate ORC Engine & Solarize	4.1	6/85	300
Hybrid ORC	4.1	3/85	100
Eval. of Vanguard Module Operation	4.2	10/84	100
Kinematic Stirling	4.2	3/85	250
Stirling Hybrid Study	4.2	9/85	100
Free Piston Stirling Engine	4.2	2/85	390
Install 1600°F SAGT	4.3	4/85	120
Advanced Engine Design	4.4	5/85	125
Engineering Development Support	5.0	1/85	100
Small Central Engine System Study	10.1	4/85	150

Table 4.3. FY85 and FY86 Deliverables

Date	Title
1984	
Nov.	FY84 Annual Report (Input to SERI) FY84 Program Summary Report (input to SERI)
Dec.	October-November Bimonthly Report
1985	
Jan.	Quarterly Review Presentation Report on Sanders Trade Study for Brayton Heat Engine SO_3 TC-T Loop Experiments at NMSU - Draft Report Transport Systems Analysis - Draft Report
Feb.	December-January Bimonthly Report Report on State of the Art in Stirling Cycle SABC Final Report
Apr.	Quarterly Review Presentation February-March Bimonthly Report Innovative Concentrator PON Preliminary Design Review - Acurex SNLA Technical Comparison of Heat Engines - Report Caterpillar IPH Project Final Report MISR Evaluation Report Distributed Receiver Solar Thermal Technology Conference and Proceedings
May	Innovative Concentrator PON Preliminary Design Review - LaJet Innovative Concentrator PON Preliminary Design Review - Entech
June	April-May Bimonthly Report Evaluation of Direct Conversion Methods vs. Heat Engines
Aug.	June-July Bimonthly Report FY84 IPH Evaluation Report
Sept.	Innovative Concentrator PON Final Design Review - Acurex Barber-Nichols Initial Test Report on ORC Dish-Electric Study Final Report Lone Star Brewery IPH Project Final REport Distributed Receiver Development Plan 1986-1987

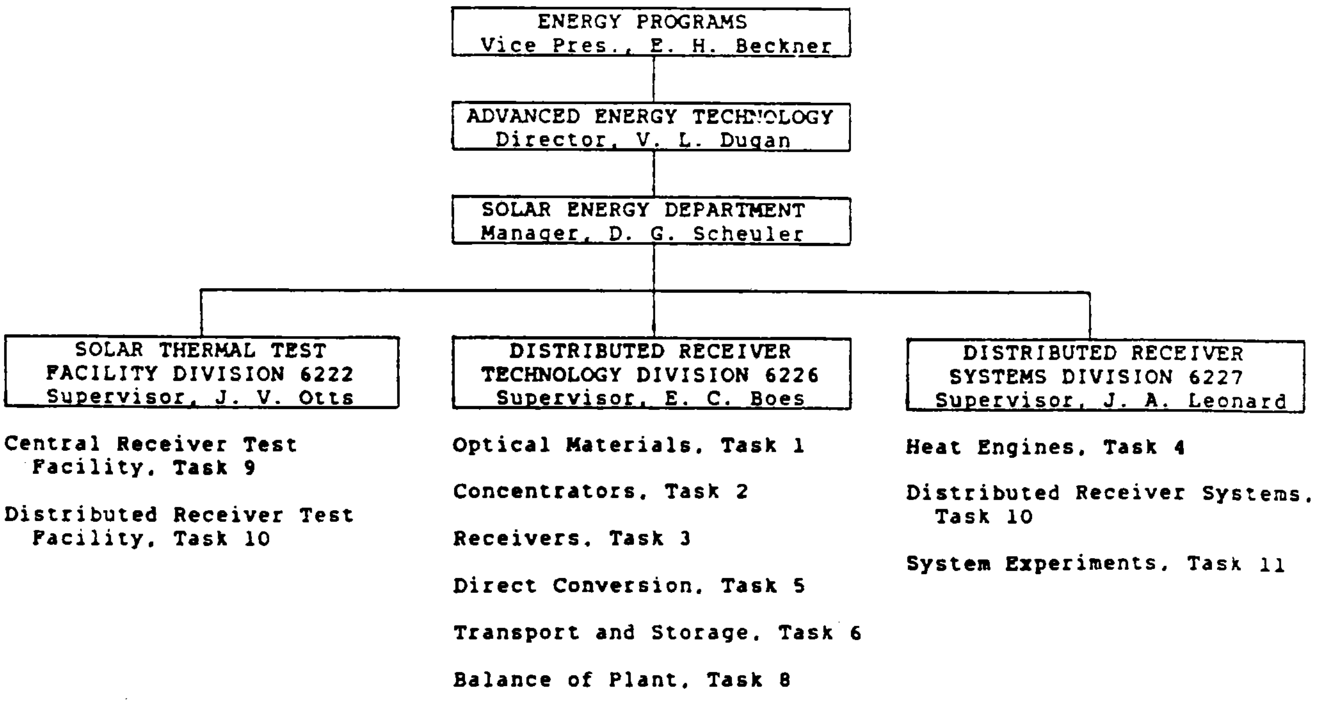
Table 4.3. continued

Date	Title
Oct.	FY85 Annual Report Input to SERI Quarterly Review Presentation August-September Bimonthly Report Assessment of DR TC-Transport Task
Nov.	Innovative Concentrator PON Final Design Review - Entech Central Engine Study Final Report
Dec.	October-November Bimonthly Report Terminal Concentrator Analysis Final Report STEP Evaluation Final Report
1986	
Jan.	Quarterly Review Presentation Innovative Concentrator PON Final Design Review - LaJet
Feb.	December-January Bimonthly Report
Mar.	Report on Line-Focus Component FY85 Contracts Cavity vs. External Receiver Study - Final Report
Apr.	February-March Bimonthly Report Quarterly Review Presentation
May	Advanced-Dish Receiver Code - Report 815°C Dish Thermal Concept Report
June	April-May Bimonthly Report
July	Quarterly Review Presentation Report on Tests of SCSE-1 Module
Aug.	June-July Bimonthly Report Hybrid Engine Study Final Report FY85 IPH Evaluation Report
Sept.	Final Report on Experimental Receiver Distributed Receiver Development Plan 1987-1988
Oct.	Quarterly Review Presentation FY86 Annual Report Input to SERI August-September Bimonthly Report

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 numerous 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 Solar Thermal Technology Projects are assigned to three 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 one-third of internal labor is provided to these Solar Thermal Projects from functional organizations.

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



RELATION OF FY84 AND FY85 TASK STRUCTURES

Figure 4.3 is a map of the relationship of the FY84 task structure, listed along the top, into the task structure used in this document's plans for FY85 and FY86.

Figure 4.3. Correlation Between FY84 and FY85 Work Breakdown Structure

FY 85 TASKS \ FY 84 TASKS	1.0 Proj Mgt	2.1 Syst Eng & Analysis	2.2 Energy Transp & Strg	2.3 Receiver Dev	2.4 Controls Dev	2.5 DRTF	2.6 Engine Dev	3.1 Shenandoah	3.2 IPH	3.3 MISR	3.4 Dish-Electric Field Exp	3.5 Tech Transfer	4.1 Dish Concentrator	4.2 CR Heliostats
1. Optical Materials				X									X	
2. Concentrators													X	X
3. Receivers				X										
4. Heat Engines							X							
5. Direct Conversion							X							
6. Transp & Strg			X											
7. Innovative Concepts														
8. Balance of Plant					X									
9. CR Systems														
10. Dist Rec Systems		X				X								
11. Syst Experiments								X	X	X	X			

REFERENCES

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.