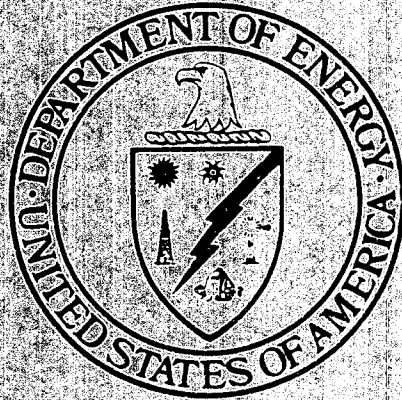


DOE/7/83-17

# FY 1983 ANNUAL OPERATING PLAN

Office of Renewable Energy Technology  
Geothermal and Hydropower Technology Division



January 1983

U.S. Department of Energy  
Forrestal Building  
Washington, D.C. 20585

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OFFICE OF RENEWABLE ENERGY TECHNOLOGY  
GEOTHERMAL AND HYDROPOWER TECHNOLOGIES DIVISION

FY 1983 ANNUAL OPERATING PLAN

JANUARY 1983

This FY 1983 Annual Operating Plan is an internal working document used to monitor and control the execution of DOE/GHTD Programs; it is, therefore, subject to changes characteristic of day-to-day program management.

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# FY 1983 GEOTHERMAL ANNUAL OPERATING PLAN

## 1.0 PROGRAM OVERVIEW

### 1.1 INTRODUCTION

There are between 700 and 3400 quads of recoverable geothermal energy in the United States. Hydrothermal, geopressure and hot dry rock are the three principal types of geothermal resources (in order of technological readiness) which can supply large amounts of energy for electric power production and direct heat applications.

Hydrothermal resources include water and steam trapped in fractured or porous rocks. A hydrothermal system is classified as either hot-water or vapor-dominated (steam), according to the principal physical state of the fluid.

Geopressured resources consist of water at moderately high temperatures at pressures higher than normal hydrostatic pressure. This water contains dissolved methane. Geopressured sources in sedimentary formations along the Texas and Louisiana Gulf Coast are believed to be quite large. Geopressured formations also exist in sedimentary basins elsewhere in the U.S.

Hot dry rock resources consist of relatively unfractured and unusually hot rocks at accessible depths that contain little or no water. To extract usable power from hot dry rock, the rock must be fractured and a confined fluid circulation system created. A heat transfer fluid is then introduced, circulated, and withdrawn.

### 1.2 PROGRAM GOAL

The overall goal of the Geothermal Program is to build a technology base that will be used by the private sector to exploit geothermal resources which can supply large amounts of energy for electric power production and direct-heat applications.

### 1.3 PROGRAM STRATEGY

The private sector is reluctant to undertake or support long-term research and development activities because they are perceived to involve high technological risk with no clear near-term financial payoff. The geothermal industrial efforts related to hydrothermal resources are proceeding on a limited, site-specific basis. The economic potential of geopressured and hot dry rock resources are not yet known.

The strategy of the Geothermal Program is to perform high-risk, high-payoff research which will build a technology base that will be used by the private sector to exploit the extensive geothermal resources. The research program is directed toward the removal and/or mitigation of technical barriers associated with wide-spread use of these resources. Federal support of this R&D is intended to ensure technology transfer to a broad industrial cross-section leading to a domestic geothermal industry.

### 1.4 CURRENT STATUS OF INDUSTRY

The U.S. has currently 1,019 MWe of electricity on line at The Geysers, CA., three 10 MWe pilot plant in the Imperial Valley, CA., and 3 MWe in Hawaii. Over 600 MWe of additional capacity is under construction, including the 50 MWe binary cycle plant at Heber, CA., which DOE is cost-sharing with industry. Direct applications of geothermal heat for space heating and industrial processing are now underway at over 30 locations. All of these facilities use hydrothermal resources. No commercial development of geopressured and hot dry rock resources is underway.

The industry infrastructure for geothermal development is too small and too fragmented to organize and finance a strong R&D response to market signals. Small geothermal companies are often not yet in a profitable enough position to benefit from tax incentives, and larger companies, for whom geothermal ventures are a sideline, often perceive too small a market to invest in R&D for geothermal needs.

## 1.5 CURRENT STATUS OF TECHNOLOGY

The process of locating, producing and utilizing large volumes of fluids from high temperature, fractured, hard rock formations imposes a number of technological and economic constraints on geothermal development which hold back resource exploitation by the private sector. Conventional oil and gas technology presently employed for exploration, drilling, reservoir assessment and production of geothermal fields has proven expensive, unreliable and frequently non-functional in the hot, chemically hostile downhole geothermal environment. Surface equipment, including power plant components, lack the efficiency and reliability of utility power generation for all except the most benign hydrothermal reservoirs. As a result, only 20 percent of the hydrothermal reservoirs above 150°C, which are generally assumed to be suitable for electric power production can be economically exploited with current technology.

Technology developments supported by DOE have resulted in the following items being commercially available:

- Magnetotelluric and passive seismic exploration techniques.
- Precipitators/clarifiers and scale inhibitors to handle high salinity, corrosive brines.
- Wellhead-size flash, total flow and binary power systems.
- High temperature elastomers and polymer concretes.
- Improved drag bit and roller bit drills, using polycrystalline diamonds and new seals and bearings.
- Water and mud driven turbodrills for directional drilling.
- Cavitating water-jet cleaning for pipes and heat exchangers.
- High-temperature electronics and sensors for well logging.

In addition to the above list of items that have reached the marketplace, the progress in resolving the technical problems associated with geothermal development includes:

- National maps of potential resources have been produced, with detailed maps for the Western states.
- About 25% of the resource is considered "discovered". Improved geophysical techniques have assisted greatly.
- About 600 wells have been drilled. Drilling costs have been reduced about 25% but remain high. Fractured zones still harder to drill than matrix-permeable rocks.
- Reservoir models for predicting production capacity and longevity are being used with limited success.
- Air quality concerns are being met, at significant cost, but injection of spent brine remains a problem.
- Binary systems, low-cost materials and components, and chemical treatments are becoming available to reduce total costs of generating facilities up to 25%, but further reductions are needed.
- Economic potential of geopressured and hot dry rock resources are not yet known.

## 1.6 PROGRAM OUTLINE

The Geothermal Program for fiscal year 1983 comprises four major sub-program elements:

- Hydrothermal Industrialization
- Geopressured Resources
- Geothermal Technology Development
- Geothermal Resources Development Fund.

Research efforts related to Hydrothermal Resources address high risks perceived by the private sector in the area of reservoir capacity and longevity; the high cost of exploration and reservoir development; commercial scale plant economics; environmental effects of production; and unproven energy extraction and conversion technologies. Under the Geopressure Resources sub-program elements, production wells are being tested to determine the magnitude, availability, and producibility of geopressured reservoirs for recovery of methane, hydraulic, and thermal energy. In addition, the technical feasibility of extracting thermal energy from Hot Dry Rock Resources is being determined by creating and operating a multifracture thermal loop of near-commercial scale at Fenton Hill, NM.

## 2.0 PROGRAM DESCRIPTION

### 2.1 PROGRAM STRUCTURE

The Geothermal Program is comprised of the following major sub-program elements and associated activities:

- Hydrothermal Industrialization
  - Resource Definition
  - Low-enthalpy Systems
  - Facilities
- Geopressured Resources
  - Reservoir Definition
  - Production Well Tests
- Geothermal Technology Development
  - Hot Dry Rock Technology
  - Hydrothermal Technology
- Geothermal Resources Development Fund.

Program activity schedules for these sub-program elements are presented in attachments la through lf.

The major program objectives for FY 1983 are to (1) complete long-lead time procurements, final design and begin construction for the Heber 50 MWe geothermal binary cycle plant and complete all other FY 82 carryover hydrothermal industrialization projects related to resource definition; (2) complete geopressured design well production tests for one well and continue flow tests for three wells; (3) complete construction and begin test of the interim reservoir system under the Fenton Hill, NM hot dry rock project; (4) continue R&D in drilling and well completion, energy conversion, reservoirs stimulation, geochemical engineering and materials, geoscience, and environment control technologies related to hydrothermal resources; and (5) complete processing of pending geothermal loan guaranty applications.

## 2.2 PROGRAM CONTENT

### 2.2.1 Hydrothermal Industrialization

The Hydrothermal Industrialization sub-program is comprised of three major activities: Resource Definition, Low-enthalpy Systems, and Facilities. The objectives of this sub-program are to confirm the reservoir potential at selected sites; evaluate the engineering and economic viability of low-enthalpy (non-electric) systems; and determine the technical and economic viability of generating electric power from moderate- to high-temperature (150°C to 200°C) liquid dominated hydrothermal resources.

### 2.2.2 Geopressured Resources

The Geopressured Resources sub-program is comprised of two major activities: Reservoir Definition (Production Well Testing) and environmental control. The objective of this sub-program is to define the extent and magnitude of the geopressured resource and to determine the technical feasibility and economics of extracting chemical, thermal and mechanical energies contained in the geopressured brines. The technical approach has been to recomplete abandoned conventional wells (wells-of-opportunity), drill four special design wells into geopressured reservoirs on the Gulf Coast for high-volume production, and conduct multi-month brine production tests to establish reservoir production characteristics.

### 2.2.3 Geothermal Technology Development

The Geothermal Technology Development is comprised of two major activities: Hot Dry Rock Technology and Hydrothermal Technology.

#### a. Hot Dry Rock Technology

The objective of this activity is to determine the technical and economic feasibility of extracting geothermal heat from hot dry rock formations. Work under this activity includes instrument and equipment development, confirmation of resource potential, and conducting energy extraction experiments at Fenton Hill, NM. The principal effort involves a three phased approach; (1) drill injection and production wells, (2) complete and operate a small interim thermal loop, and (3) complete and operate a final (large) thermal loop at the Fenton Hill site. This effort is being conducted under an IEA Agreement. Multiple-fracture experiments have been conducted in the injection and production wells. Progress in establishing multiple connections between boreholes has been hampered by unexpected fracture geometry in the reservoir.

### 2.2.3 Geothermal Technology Development (Con't)

#### b. Hydrothermal Technology

The goal of the Hydrothermal Technology activity is to expand the economically exploitable hydrothermal resource base available for development by the private sector by conducting R&D directed toward reducing the cost of exploration, reservoir assessment and field development; capital costs of electric generating facilities; and the technical risks of fluid handling. The current R&D activities are directed toward:

- Reducing geothermal exploration and hard rock drilling cost.
- Increasing moderate temperature energy conversion efficiencies through binary cycle technology development.
- Increasing reservoir production rates with well stimulation and downhole brine pumps.
- Extending component life and reliability through improved geochemical engineering and materials development.
- Improving reservoir engineering methods for assessing site-specific capacity and longevity.
- Developing environmental control technology required to meet state and federal standards for geothermal emissions and waste disposal.

The Hydrothermal Technology activity is composed of six major sub-activities: Drilling and Well Completion, Energy Conversion, Geochemical Engineering and Materials, Geoscience and Environmental Control Technologies.

### 2.2.4 Geothermal Resource Development Fund

The objectives of the Geothermal Loan Guaranty program are to encourage and assist the private and public sectors to accelerate the utilization of geothermal resources by minimizing the lender's financial risk; to develop a financial service infrastructure to ultimately provide financing of geothermal project without Federal assistance; and to promote competition and encourage new entrants into the marketplace. The loan guaranty program was suspended at the end of FY 1981. However, in January of 1982 the Secretary of Energy made a commitment to the applicants and the Congress that the eleven applications pending in DOE at that time and the potential follow-ons would be processed expeditiously in accordance with the procedures prescribed in the current regulations. Of the eleven applications that were pending in January 1982, decisions have been made on seven. Three are still in process and one is on hold. Continuing effort involves evaluation of remaining loan guaranty applications; monitoring of 5 on-going projects; and the negotiaton and execution of 4 new loan guaranties.

### 3.0 PROGRAM ACTIVITIES (FY 1983)

Research and development activities planned for FY 1983 are outlined below following the program structure presented in section 2.1.

#### 3.1 HYDROTHERMAL INDUSTRIALIZATION (FY 83 B.A.-\$56.5 Million)

##### 3.1.1 ACTIVITY: Resource Definition

###### OBJECTIVES:

To confirm the existence of hydrothermal reservoirs, to evaluate the resource potential and geographic distribution, and to test advanced methods of reservoir definition.

###### SUB-ACTIVITIES:

- User-coupled Reservoir Confirmation Drilling Projects
- State-coupled Resource Assessment Projects
- Reservoir Characterization
- Raft River Brine Injection Experiment

###### PLANNED FY 83 ACTIVITIES

All FY 1982 carry-over efforts relating to resource definition will be completed including the characterization of the Steamboat Springs and Moana reservoirs and the Raft River brine injection experiment.

FUNDING (FY 83): \$1.5 Million

##### 3.1.2 ACTIVITY: Low Enthalpy Systems

###### OBJECTIVE:

To evaluate the engineering and economic viability of low-enthalpy (non-electric) systems.

###### SUB-ACTIVITIES:

- Engineering and economic feasibility studies of non-electric applications
- Direct heat field experiments

###### PLANNED FY 83 ACTIVITIES:

All seven FY 1982 carry-over direct-heat field experiments and two non-electric engineering feasibility studies will be completed. A hybrid plant engineering feasibility study relating to a proposed Honey Lake, CA project will also be completed.

FUNDING (FY 83): \$2.5 Million

3.1.3 ACTIVITY: Facilities

OBJECTIVE:

To determine the technical and economic viability of generating electric power from moderate- to high-temperature (150°C to 200°C) liquid-dominated hydrothermal reservoirs.

SUB-ACTIVITIES:

- Baca 50 MWe Geothermal Flash Steam Plant
- Raft River 5 MWe Binary Cycle Pilot Plant
- Heber 50 MWe Geothermal Binary Cycle Plant
- Heber R&D Support

PLANNED FY 83 ACTIVITIES:

Final reports will be issued for the Baca 50 MWe geothermal flash steam plant and the Raft River 5 MWe geothermal binary pilot plant. The principal efforts associated with Heber 50 MWe geothermal binary cycle plant include the initiation of well field development; completion of final design and long lead-time equipment; and start of construction. R&D support for the Heber project will include the field test of corrosion rates for heat exchanger and pipe materials; fabrication of a CO<sub>2</sub> monitoring probe; and development of a computer model for power cycle/heat exchanger optimization.

FUNDING (FY 83): \$52.5 Million for the Heber Project

3.2 GEOPRESSURED RESOURCES (FY 83 B.A. - \$8.4 MILLION)

3.2.1 ACTIVITY: Environmental Control

OBJECTIVES:

To determine the environmental effects producing geopressured fluids.

SUB-ACTIVITIES:

- Reservoir Sampling with Wells-of-Opportunity

3.2.2 ACTIVITY: Resource Definition

OBJECTIVES:

To define the extent and magnitude of the geopressured resource, and determine the technical feasibility and economics of extracting chemical, thermal and mechanical energies contained in geopressured brines.

SUB-ACTIVITIES:

- Design Well Production Test

PLANNED FY 83 ACTIVITIES for 3.2.1 and 3.2.2:

The major effort will involve the orderly phase-out of all R&D activities following guidance that the resource base will now be developed by private industry as economic conditions dictate. One design wells will be shut-down, plugged and abandoned. Production test of one Texas and two Louisiana wells will be continued; results published for two design wells production tests; and environmental monitoring continued for wells undergoing production tests.

FUNDING (FY 83): \$8.4 Million

### 3.3 GEOHERMAL TECHNOLOGY DEVELOPMENT (FY 83 B.A. 15.0 Million)

#### 3.3.1 ACTIVITY: Hot Dry Rock Technology

##### OBJECTIVE:

To determine the technical and economic feasibility of extracting geothermal heat from hot dry rock formations.

##### SUB-ACTIVITIES:

- Resource Definition
- Instrument and Equipment Development
- Energy Extraction Experiments of Fenton Hill, NM

##### PLANNED FY 83 ACTIVITIES:

Multiple - fracture experiments have been conducted in the injection and production wells drilled at the Fenton Hill, NM site. Progress in establishing multiple connections between boreholes has been hampered by unexpected fracture geometry in the reservoir. During FY 1983 work will include establishing multiple, low-impedence connections between the injection and producing wells forming the interim thermal loop for the small interim reservoir system and start of design and procurement of the surface hardware for the larger, final system.

FUNDING (FY 83): \$7.5 Million. West Germany and Japan are scheduled to contribute an additional \$2.5 million each to the project.

#### 3.3.2 ACTIVITY: Hydrothermal Technology

##### OBJECTIVE:

To reduce the cost of exploration, reservoir assessment, and field development; the capital costs of electric generating facilities; and the technical risks of fluid handling.

##### SUB-ACTIVITIES:

- Drilling and Well Completion Technology
- Energy Conversion Technology
- Reservoir Stimulation Technology
- Geochemical Engineering & Materials
- Geoscience Technology
- Environmental Control Technology

##### PLANNED FY 83 ACTIVITIES:

R&D efforts will be conducted under the six sub-activities as outlined in sections 3.3.2.1 through 3.3.2.6

FUNDING (FY 83): \$7.5 Million

3.3.2.1 SUB-ACTIVITY: Drilling and Well Completion Technology

OBJECTIVES:

To develop drilling and well completion technology capable of reducing the field development costs by 25 percent and to develop technology necessary to achieve an additional 25 percent reduction in the field development cost through advanced and innovative methods.

TASKS:

- Rock Penetration Mechanics
- Drilling Fluid Technology
- Borehole Mechanics
- Diagnostics Technology

PLANNED FY 83 ACTIVITIES:

Work will include laboratory percussion test of rock/cutter interactions, study of aqueous foam for lost circulation control, acoustic performance test of cement bond log, and test of materials in the lost circulation control facility.

3.3.2.2 SUB-ACTIVITY: Energy Conversion Technology

OBJECTIVES:

To develop energy conversion technology capable of exploiting moderate temperature (150°C to 200°C) reservoirs; to reduce the cost of heat exchangers by 20 percent and improve the efficiency of binary cycle systems by 30 percent; and modify and test electric downhole brine pumps leading to improved capability to maintain fluid production and reduce downhole flashing and scaling.

TASKS:

- Binary Cycle Technology
- Total Flow Systems
- Downhole Brine Pumps

PLANNED FY 83 ACTIVITIES:

R&D efforts will include study of IC4/IC5 hydrocarbon mixture properties; field test of the helical screw expander (total flow system) in New Zealand under an IEA agreement; field evaluation of the 500 kWe direct contact heat exchanger prototype binary cycle plant; and initial test of a super-critical boiler in the 60 kWe system relocated to the Geothermal Test Facility at East Mesa, CA.

3.3.2.3 SUB-ACTIVITY: Reservoir Stimulation Technology

OBJECTIVE:

To develop techniques for increasing well flow rates and extending the life of production and injection wells.

TASKS:

- Evaluation of Well Stimulation Techniques
- Proppants and Frac Fluids
- Well Stimulation Experiments

PLANNED FY 83 ACTIVITIES:

Primary efforts include the evaluation of the design of the Tailored Pulse Loading (T.P.L.) well stimulation technique, test of the acoustic borehole televiewer device for wellbore fracture mapping, and completion of the final DOE/Industry cost-shared well stimulation experiment.

3.3.2.4 SUB-ACTIVITY: Geochemical Engineering & Materials

OBJECTIVE:

To develop geochemical engineering techniques and materials capable of increasing equipment life, plant reliability, and reducing the cost of fluid handling.

TASKS:

- Fluid Characterization
- Geochemical Monitoring and Control
- Fluid Handling
- Materials for Borehole Components
- Materials for Energy Conversion Components
- Materials Testing and Corrosion Control

PLANNED FY 83 ACTIVITIES:

R&D efforts include a study of carbonate and silica high-temperatures/pressure reactions, evaluation of the U.S.-Mexico high temperature cement test data, field test of a cathodic protection technique, high-temperature test of a fluorinated elastomer, and field test of pH and isobutane probes.

3.3.2.5 SUB-ACTIVITY: Geoscience Technology

OBJECTIVES:

To develop reliable, cost-effective techniques for locating and identifying geothermal reservoirs thereby increasing the success rates for exploration well drilling; and to develop reservoir engineering techniques capable of providing an estimate of reservoir capacity, forecasting reservoir depletion rates, and estimating optimum production and injection procedures for heat extraction.

TASKS:

- Exploration Technology
- Reservoir Engineering

PLANNED FY 83 ACTIVITIES:

Primary efforts include characterization of Cascades-type reservoirs in California, Oregon, and Washington; evaluation of diagnostic seismic characteristics of hydrothermal reservoirs; development of numerical models of reservoirs undergoing long-term production and injection; and the development of improved tracer techniques to validate reservoir models for predicting fluid migration.

3.3.2.6 SUB-ACTIVITY: Environmental Control Technology

OBJECTIVES:

To identify potentially damaging emissions, discharges, and induced geologic changes resulting from geothermal operations; and to develop cost-effective detection, prediction, prevention, control and mitigation techniques for environmentally damaging events related to geothermal energy development.

TASKS:

- Emissions Characterization and Effects Identification
- Monitoring Technology Development
- Control Technology Development

PLANNED FY 83 ACTIVITIES:

The main efforts will be the test of the electron-beam H<sub>2</sub>S abatement process, test of the direct chlorination H<sub>2</sub>S process, and completion of a field test report on induced seismicity.

### 3.4 GEOHERMAL RESOURCES DEVELOPMENT (FY 83 B.A. \$0.0 Million)

#### OBJECTIVE:

To encourage development of geothermal resources by the private and public sector through a geothermal loan guaranty program which minimizes the lender's risk, develops a financial service infrastructure, promotes competition, and encourages new entrants into the market place.

#### ACTIVITIES:

- Monitoring of Five On-going Projects
- Evaluation of Pending Loan Guaranty Applications
- Negotiation and Execution of New Loan Guaranties

#### PLANNED FY 83 ACTIVITIES:

The loan guaranty program was suspended at end of FY 1982. A committment was made to process eleven loan guaranty applicatins pending as of January 1, 1982 and potential follow-on loans for approved projects. The evaluation of nine applications has resulted in 4 approvals, 1 disapproval, 3 withdrawals and 1 returned for updating. The four new loan approvals amount to \$153.4 million in loan authority. The principal effort in FY 1983 will be complete the evaluation of remaining loan guaranty applica-tions, the negotiation and execution of the four new loan guaranty agreements, and the monitoring of five on-going projects.

FUNDING: \$ 6.9 Million

## 4.0 MANAGEMENT PLAN

### 4.1 Assigned Responsibilities

#### a. Headquarters:

Through the Interagency Geothermal Coordinating Council (IGCC) the Assistant Secretary for Conservation and Renewable Energy (ASCE) has the lead responsibility for coordination with other agencies in the execution of the overall Federal Geothermal Energy Program. The DOE Geothermal Program is under the ASCE and assigned to the Office of Renewable Technologies (RT). Through his Deputy Assistant Secretary for Renewable Energy (DASRE), the ASCE develops and provides policy guidance to the Director, RT regarding implementation of DOE policy and approves specific program strategies and plans to be pursued.

The Director, RT interprets ASCE policy guidance, recommends policy revisions, develops program strategies and resource requirements, and executes the approved strategy.

The Director, Geothermal and Hydropower Technologies Division (GHTD), prepares program plans and executes approved plans within overall costs and schedules working through the appropriate field organizations for implementation.

At each level (ASCE, DSRE, Office Director and Division Director) program execution is monitored and performance is measured against the approved plans. Appropriate management and technical review systems are in place.

The Director, GHTD exercises program responsibilities through four branches. The organizational structure is shown in Attachment 2.

#### b. Field Offices:

The general management policy of the Office of the Assistant Secretary for Conservation and Renewable Energy (ASCE) is to accomplish its missions through a decentralized organization for programs/project execution. Technical direction of specified program areas will be carried out by field technical organizations and all defined projects will be managed by field organizations.

In general, the field offices will implement the program plans, direct the contractors and review their performance, and provide Headquarters with recommendations on program needs, direction and control.

#### 4.1 Assigned Responsibilities (Con't)

##### c. National Laboratories:

DOE laboratories are responsible for accomplishing assigned R&D under various program elements. Los Alamos National Laboratory (LANL), Lawrence Berkeley Laboratory (LBL), Idaho National Engineering Laboratory (INEL), Pacific Northwest Laboratory (PNL) and Sandia National Laboratory (SNL) are the major laboratories which support GHTRD's program. The assignment of technical areas among DOE field offices and laboratories is shown in Attachment 3.

#### 4.2 Major Milestones:

ASCE and RT controlled milestones selected for tracking program progress in FY 1983 are presented in Attachment 4.

#### 4.3 Major Projects:

The 50 MWe Geothermal Binary Cycle Plant at Heber, CA. is designated a key project in the GHTRD's program. The project summary for this major effort is presented in Attachment 5.

#### 4.4 Project Management:

- a. Formal project reviews will be held periodically to evaluate progress of research and development activities and assure on a continuing basis that the project's objectives and direction are compatible with the overall program plan.
- b. A Management-by-Objectives (MBO) plan will be established and implemented.
- c. Status reports will be required of the contractors on a regular basis in order to evaluate monitor and control costs, schedule, and technical requirements against baseline plans.

## 5.0 RESOURCE REQUIREMENTS

- 5.1 Total Geothermal budget authority and outlays for FY 1983 and expenditures for prior years are shown in Attachment 6.
- 5.2 Attachment 7 summarizes the FY 83 allocations of operating expenses to performing institutions and among R&D categories. Attachment 8 gives the planned cumulative buildup of obligational authority and operating costs for FY 1983.

# KEY ACTIVITY SCHEDULE

**DIVISION:** Geothermal and Hydropower Technologies Division  
**DIVISION DIRECTOR:** Dr. John E. Neck

Attachment 1(a)

OBJECTIVES/ACTIVITIES	\$ RESOURCES NEW FY 83 BA + UNOBLIGATED CARRYOVER	FISCAL YEAR 1983				FISCAL YEAR 1984			
		1st QTR	2nd QTR	3rd QTR	4th QTR	1st QTR	2nd QTR	3rd QTR	4th QTR
<b>A. HYDROTHERMAL INDUSTRIALIZATION</b>	\$56,500,000								
<b>1. Resource Definition</b>	(1,500,000)				▲ Vale, OR Project			▼	
- User-coupled Reservoir Confirmation Drilling			▲ Steamboat Spgs & Moana						
- Reservoir Characterization			▲ Raft River	▲ RFP	▲ Newberry Caldera			▼	
- Brine Injection Experiments					▲ Industry Site			▼	
<b>2. Low Entalphy Systems</b>	(2,500,000)				▲ Hybrid Plant Study				
- Engineering & Economic Feasibility Studies			▼						▲ Final Report
- Direct Heat Field Experiments			▲ Boise Project Dedication		▲ Seven Projects			▲ Nine Projects	▼
<b>3. Facilities</b>	(52,500,000)								
- Baca 50 MWe Geothermal Flash Steam Plant			▲ Site Restoration	▲ Equipment Options	▲ Sales Options				
- Raft River 5 MWe Binary Cycle Pilot Plant					▲ Final Report				
- Heber 50 MWe Geothermal Binary Cycle Plant			▲ Final Design		▲ Cooperative Agreement Modification				
- Heber R&D Support			▲ Corrosion Test Coupons		▲ CO <sub>2</sub> Probe Fabrication			▲ Well Drilling	
					▲ Construction			▲ CO <sub>2</sub> Probe Field Test	
					▲ System Computer Model			▲ System Model Verification	

ASCE Controlled Milestone    
  ORT-Controlled Milestone    
  Begin Milestone    
  Complete Milestone    
  Decision Milestone

5T

# KEY ACTIVITY SCHEDULE

**DIVISION:** Geothermal and Hydropower Technologies Division

**DIVISION DIRECTOR:** John E. Mock

Attachment 1(b)

OBJECTIVES/ACTIVITIES	\$ RESOURCES NEW FY 83 BA + UNOBLIGATED CARRYOVER	FISCAL YEAR 1983				FISCAL YEAR 1984			
		1st QTR	2nd QTR	3rd QTR	4th QTR	1st QTR	2nd QTR	3rd QTR	4th QTR
<b>B. GEOPRESSURED RESOURCES</b>	\$ 8,400,000								
<b>1. Environmental Control</b>									
- Environmental Monitoring				Chemical △ Analyses					
<b>2. Reservoir Definition - Design Well Tests</b>									
- Parcperdue, LA		▽		▽ Plug & Abandon		▽ Final Report			
- Gladys McCall, LA		▲					▽		▽ Final Report
- Pleasant Bayou, TX								▽	
- Sweet Lake, LA				● Decision to Begin Test				▽	▽ Final Report
<b>C. GEOTHERMAL TECHNOLOGY DEVELOPMENT</b>	\$15,000,000 ( 7,500,000)								
<b>1. Hot Dry Rock Technology</b>									
- Instrument and Equipment Development			▽ Fluid Sampler	▽ "Stim Tools"			▽ Fracture Zone Isolation Tool		
- Fenton Hill Heat Extraction Experiment		△ Interim Reservoir System Fracture Operations			▽ Final System Design & Procurement		▲ Interim System Test	▽	▽ Final System Fracture Planning

△ ASCE Controlled Milestone
▲ ORT-Controlled Milestone
△ Begin Milestone
▽ Complete Milestone
○ Decision Milestone

# KEY ACTIVITY SCHEDULE

**DIVISION:** Geothermal and Hydropower Technologies Division

Attachment 1(c)

**DIVISION DIRECTOR:** John E. Mock

OBJECTIVES/ACTIVITIES	\$ RESOURCES NEW FY 83 BA + UNOBLIGATED CARRYOVER	FISCAL YEAR 1983				FISCAL YEAR 1984								
		1st QTR	2nd QTR	3rd QTR	4th QTR	1st QTR	2nd QTR	3rd QTR	4th QTR					
<p><b>C. GEOTHERMAL TECHNOLOGY DEVELOPMENT</b></p> <p>2. <u>Hydrothermal Technology</u></p> <p>(a) <u>Drilling and Well Completion Technology</u></p> <p style="margin-left: 20px;">- Rock Penetration Mechanics</p> <p style="margin-left: 20px;">- Drilling Fluid Technology</p> <p style="margin-left: 20px;">- Borehole Mechanics</p> <p style="margin-left: 20px;">- Diagnostics Technology</p> <p>(b) <u>Energy Conversion Technology</u></p> <p style="margin-left: 20px;">- Binary Cycle Technology</p> <p style="margin-left: 20px;">- Total Flow Systems</p> <p style="margin-left: 20px;">- Downhole Brine Pumps</p>	<p>( 7,500,000)</p>													
		▲	▲	▲	▲					▲				
				▲	▲									▲
		▲		▲	▲									▲
				▲	▲									▲
		▲		▲	▲									▲
				▲	▲									▲
		▲		▲	▲									▲

▲ ASCE-Controlled Milestone
▲ ORT-Controlled Milestone
▲ Begin Milestone
▼ Complete Milestone
○ Decision Milestone

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## KEY ACTIVITY SCHEDULE

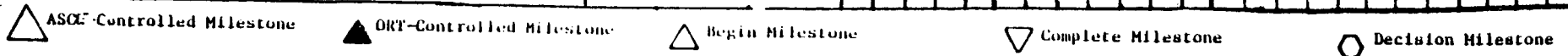
**DIVISION:** Geothermal and Hydropower Technologies Division

**DIVISION DIRECTOR:** John E. Mock

Attachment 1(d)

OBJECTIVES/ACTIVITIES	\$ RESOURCES NEW FY 83 BA + UNOBLIGATED CARRYOVER	FISCAL YEAR 1983				FISCAL YEAR 1984			
		1st QTR	2nd QTR	3rd QTR	4th QTR	1st QTR	2nd QTR	3rd QTR	4th QTR
<b>C. GEOTHERMAL TECHNOLOGY DEVELOPMENT</b>									
<b>2. Hydrothermal Technology (con't)</b>									
<b>(c) Reservoir Stimulation Technology</b>									
- Evaluation of Well Stimulation Techniques				TPL Feasibility Study			Final Report		
- Well Stimulation Experiments			Acid Treatment ICA Site		Final Report				
<b>(d) Geochemical Engineering &amp; Materials</b>									
- Fluid Characterization					Carbonate & Silica Study				
- Geochemical Monitoring and Control		pH & Isobutane Probe Field Test						Final Report	
- Fluid Handling							Brine Injection Handbook		
- Materials for Borehole Components					Fluorinated Elastomer Field Test				
- Materials for Energy Conversion Components				Materials Test at GTF					
- Materials Testing and Corrosion Control		US-Mexico Cement Tests			Cathodic Protection Field Test				

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# KEY ACTIVITY SCHEDULE

**DIVISION:** Geothermal and Hydropower Technologies Division

**DIVISION DIRECTOR:** John E. Mock

Attachment 1(e)

OBJECTIVES/ACTIVITIES	\$ RESOURCES NEW FY 83 BA + UNOBLIGATED CARRYOVER	FISCAL YEAR 1983				FISCAL YEAR 1984			
		1st QTR	2nd QTR	3rd QTR	4th QTR	1st QTR	2nd QTR	3rd QTR	4th QTR
<p><b>C. GEOTHERMAL TECHNOLOGY DEVELOPMENT</b></p> <p>2. <u>Hydrothermal Technology (con't)</u></p> <p>(e) Geoscience Technology</p> <p style="padding-left: 20px;">- Exploration Technology</p> <p style="padding-left: 20px;">- Reservoir Engineering</p> <p>(f) Environmental Control Technology</p> <p style="padding-left: 20px;">- Emissions Characterization and Effects Identification</p> <p style="padding-left: 20px;">- Monitoring Technology Development</p> <p style="padding-left: 20px;">- Control Technology Development</p>		<p>Seismic Reflection Data</p>	<p>R.H.S. Tracer Tests</p>	<p>R.H.S. Fault Control</p> <p>Klamath Falls Study</p>	<p>Cascades Study</p> <p>Gas Partitioning Model</p> <p>Solid Waste Characterization</p> <p>Induced Seismicity Report</p> <p>Electron Beam H<sub>2</sub>S Process</p>	<p>Seismic Properties of Reservoirs</p>	<p>Direct Chlorination Field Test</p>		

ASCE-Controlled Milestone    
  ORT-Controlled Milestone    
  Begin Milestone    
  Complete Milestone    
  Decision Milestone

# KEY ACTIVITY SCHEDULE

**DIVISION:** Geothermal and Hydropower Technologies Division  
**DIVISION DIRECTOR:** John E. Mock

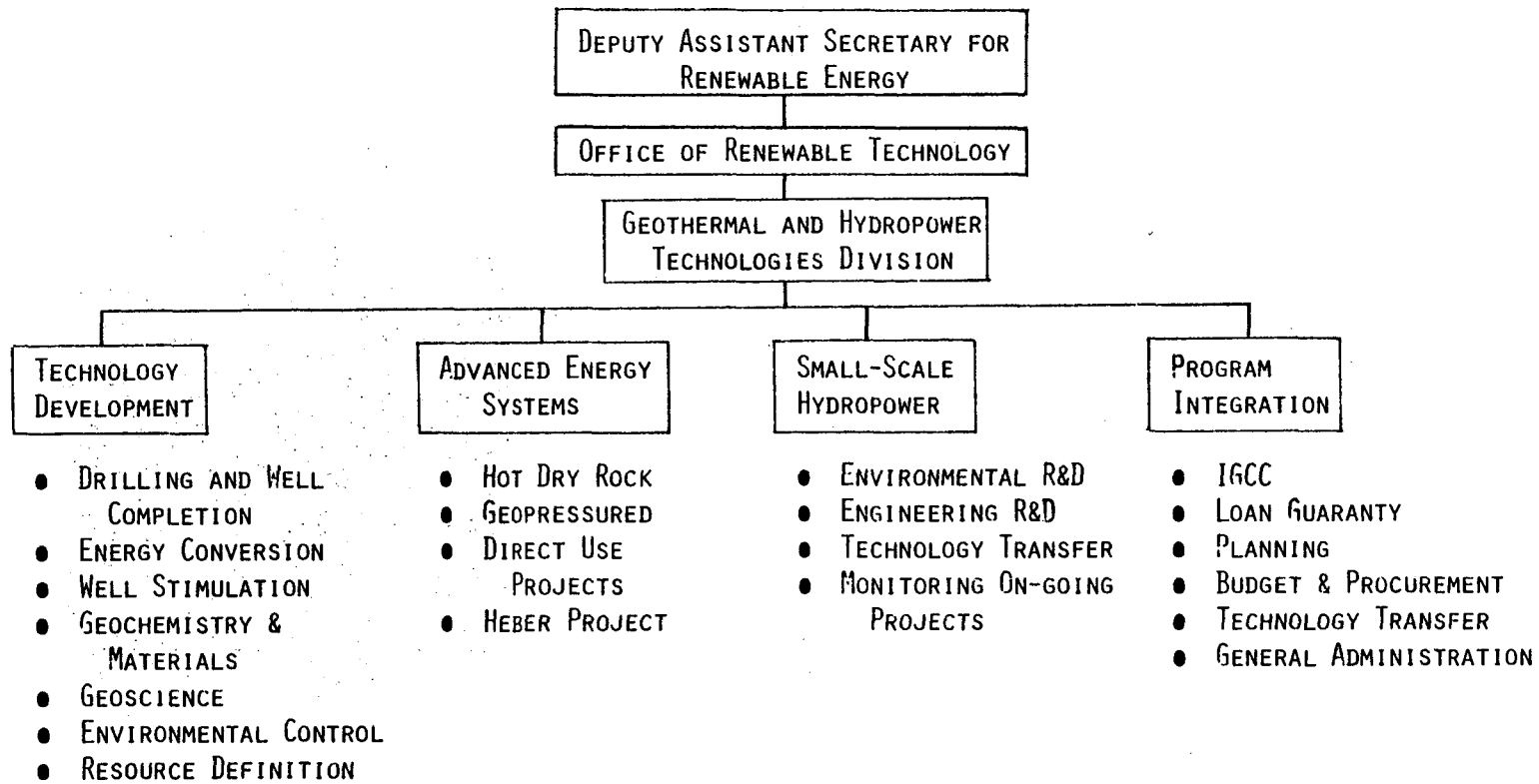
Attachment 1(f)

OBJECTIVES/ACTIVITIES	\$ RESOURCES NEW FY 83 BA + UNOBLIGATED CARRYOVER	FISCAL YEAR 1983				FISCAL YEAR 1984			
		1st QTR	2nd QTR	3rd QTR	4th QTR	1st QTR	2nd QTR	3rd QTR	4th QTR
<b>D. GEOTHERMAL RESOURCES DEVELOPMENT FUND</b>	\$ 6,900,000								
1. <u>Monitoring of Approved Loan Guaranty Projects</u>									
2. <u>Processing of Pending Loan Applications</u>									
3. <u>Negotiation &amp; Execution of New Loan Guaranties</u>									
<b>E. PROGRAM INTEGRATION</b>									
1. <u>Interagency Geothermal Coordinating Council (IGCC) Activities</u>									
2. <u>Management of Support Service Activities for DGHT and ORT</u>									
3. <u>Coordination of Division Input to Major ORT Presentations</u>									

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ASCE-Controlled Milestone    
  ORT-Controlled Milestone    
  Begin Milestone    
  Complete Milestone    
  Decision Milestone

GEOTHERMAL AND HYDROPOWER TECHNOLOGIES DIVISION  
ORGANIZATION



MANAGEMENT OPERATIONAL PLAN:

DAS FOR RENEWABLE ENERGY

OFFICE OF RENEWABLE TECHNOLOGY

GEOHERMAL AND HYDROPOWER TECHNOLOGIES DIVISION

Technology Development Branch

Program Integration Branch

Advanced Energy Systems Branch

San Francisco Operations Office

Idaho Operations Office

Albuquerque Operations Office

Nevada Operations Office

LBL

INEL

Sandia

LANL

- Geoscience Technology
- Energy Conversion
- Geochemical Engineering
- Materials Research
- Geoscience Technology
- Environmental Control
- Resource Definition
- Heber 50 MWe Plant
- Direct Heat Exp. & Studies
- Geothermal Resources Dev. Fund

- Energy Conversion
- Resource Definition
- Hydropower Demos, R&D, Tech Transfer & Loan Monitoring
- Geoscience Technology
- Direct Heat Exp. & Studies

- Drilling Technology
- Reservoir Stimulation
- Hot Dry Rock Research
- Brine Pump Development
- Reservoir Stimulation

- Geopressured Resources

## ATTACHMENT 4

MAJOR MILESTONES (FY 1983)

## Geothermal Program

## ASCE Controlled (1) &amp; RT Controlled (2) Milestones

ACTIVITY TITLE (BRC)	MILESTONES	DATE	TYPE
<b>A. <u>HYDROTHERMAL INDUSTRIALIZATION</u></b>			
<b>1. <u>Resource Definition</u></b> (AM-15-10-0)	Begin Evaluation of Geologic & Hydro- logic Characteristics of Moana & Steamboat Spgs. Reservoirs	Oct '82	-
	Begin Newberry Caldera Reservoir Characterization	Dec '82	-
	Complete Raft River Injection Experiment	Dec '82	2
	Due date for Response to RFP covering Selection of Industry Injection Site	Feb '83	-
	Select Industry Brine Injection Site	Apr '83	2
	Complete Negotiations for Vale, OR User-Coupled Reservoir Confirm- ation Project	May '83	2
<b>2. <u>Low-Enthalpy Systems</u></b> (AM-15-15-0)	Complete all carry-over FY 82 Engineering and Economic Feasibility Studies	Dec '82	-
	Boise Project Dedication	Feb '83	2
	Complete Seven direct Heat Field Experiments	June 83	2
	Complete Hybrid Plant Engineering Feasibility Study	Sept '83	-

A. HYDROTHERMAL INDUSTRIALIZATION

3. Facilities  
(AM-15-25-10)

- Baca 50 MWe Geothermal Flash Steam Plant	Complete Site Restoration	Nov '82	-
	Complete Formulation of Equipment Sales Options	Feb '83	2
	Issue Final Report	Mar '83	-
- Raft River 5 MWe Geothermal Plant	Issue Final Report	Mar '83	-
- Heber 50 MWe Geothermal Binary Cycle Plant	Complete Final Design	Nov '82	2
	Sign Cooperative Agreement Modification	Dec '82	1
	Begin Construction	Feb '83	2
	Complete Major Foundations	Apr '83	-
	Complete Fabrication of Test Coupons and Begin Field Test of Corrosion Rates for Heat Exchanger and Pipe Materials	Jan '83	-
	Begin Fabrication of CO <sub>2</sub> Probe	Apr '83	-
- Heber R&D Support	Complete Computer Model Development for Power Cycle/Heat Exchanger Optimization	Aug '83	2
	Complete Fabrication of CO <sub>2</sub> Probe	Sept '83	-

B. GEOPRESSURED RESOURCES  
(AM-05-10-00)

1. <u>Environmental Control</u>	Begin Gas/Fluid Sampling and Analysis Routine at Design Wells	Apr '83	-
2. <u>Reservoir Definition</u> (Design Well Tests)	Plug and abandon the Parcperdue, LA Design Well	Mar '83	2
	Decision to Begin Test of Sweet Lake, LA Design Well	Apr '83	2
	Complete repair and begin long term testing of Gladys McCall, LA and Sweet Lake, LA, Design Wells	May '83	2

C. GEOHERMAL TECHNOLOGY DEVELOPMENT

1. <u>Hot Dry Rock Technology</u> (AM-10-10-00)	Complete Development of Downhole Fluid Sampler	Dec '82	-
	Complete Fracture Operations for Reservoir System at Fenton Hill	Jul '83	2
	Begin Design & Procurement of Final System Hardware	Aug '83	1
2. <u>Hydrothermal Technology</u> (AM-10-05-00)			
- Drilling and Well Completion Technology (AM-10-05-05)	Complete Laboratory Percussion Tests of Rock/Cutter Interaction	Nov '82	2
	Complete Heat Properties Study of Aqueous Foam for Lost Circulation Control	Jan '83	-

C. GEOHERMAL TECHNOLOGY DEVELOPMENT

2. Hydrothermal Technology

- Drilling and Well Completion (Con't)

Complete PDC Bit Test at Imperial Valley Site	Feb'83	-
Complete Acoustic Performance Tests for Cement Bond Log	July'2	2
Complete Design of Lost Circulation Zone Mapping Tool (LCZMT)	Aug'83	-
- Energy Conversion Technology (AM-10-05-10)		
Complete Test of 80 H.P. REDDA Brine Pump	Oct'82	2
Complete Evaluation of Direct Contact Heat Exchanger (DCHX) Pilot Plant	Nov'82	2
Complete Skid-Mount of 60 kWe Unit	Mar'83	-
Begin Super-critical Boiler Test with 60 kWe Unit at Geothermal Test Facility, East Mesa, CA.	May'83	2
Complete Field Test of Helical Screw Expander in New Zealand under IEA Agreement	July'83	1
Begin Field Test of 300 H.P. Brine Pump	Aug'83	-
Complete Study of IC4/IC5 Hydrocarbon Mixture Properties	Sept'83	-

C. GEOHERMAL TECHNOLOGY DEVELOPMENT

2. Hydrothermal Technology (Con't)

- Reservoir Stimulation Technology (AM-10-05-15)	Initiate Final Well Stimulation Experiment (Acid Treatment) at Industry Site	Mar '83	2
	Complete Tailored Pulse Loading (TPC) Feasibility Study	Apr '83	-
- Geochemical Engineering and Materials Research (AM-10-05-20)	Begin Field Test of pH and Isobutane Probes	Oct '82	2
	Begin Phase I Geophysical Injection Monitoring Tests	Nov '82	-
	Complete Evaluation of US- Mexico High Temperature Cement Test Data	Jan '83	2
	Complete Cathodic Protection Field Test	June '83	2
	Complete Florinated Elastomer High Temperature Test	Aug '83	-
	Complete Carbonate & Silica H.T./Pressure Reaction Study	Sept '83	-
- Geoscience Technology (AM-10-05-25)	Begin Development of Data Processing Techniques for Seismic Reflection Data Gathered over Reservoirs	Oct '82	-
	Complete Analysis of Roosevelt Hot Springs Tracer Tests	Jan '83	2
	Begin Klamath Falls Reservoir Study	Mar '83	2

C. GEOHERMAL TECHNOLOGY DEVELOPMENT

2. Hydrothermal Technology

- Geoscience Technology (Con't)	Complete Annalysis of Fault Control on Roosevelt Hot Springs Reservoir	Apr'83	-
	Complete Gas Portioning Model Development & Evaluation	July'83	-
- Environment Control Technology (AM-10-05-30)	Issue Geysers Field Test Report on Induced Seismicity	Mar'83	-
	Complete Test of Electron Beam H <sub>2</sub> S Abatement Process	June'83	2
	Complete Field Test of Direct Chlorination H <sub>2</sub> S Process	Sept'83	2

D. GEOHERMAL RESOURCES DEVELOPMENT FUND

1. Processing of Pending Loan  
Applications

Complete Evaluation of Loan Guaranty for Ultrasweet Project	Oct'82	1
Complete Evaluation of Loan Guaranty for Niland Project	Dec'82	1
Report to Congress on Status of Pending Loan Applications	Jan'83	1

2. Negotiation and Execution of New  
Loan Guaranties

Execute Loan Guaranty for Boise Project	Mar'83	1
--	--------	---

E. PROGRAM INTEGRATION

Prepare material for Semi- annual meeting of Interagency Geothermal Coordinating Council (IGCC)	Oct'82; Apr'83	1
Prepare Final Draft of IGCC Annual Report No. 7 (FY82)	Mar'83	2

E. PROGRAM INTEGRATION (Con't)

Submit Annual Operating Plan for FY83	Mar '83	2
Submit Technology Transfer Plan for FY83	Mar '83	2
Issue DOE Laboratory Technology Status Report	Feb '83	2

ATTACHMENT 5

KEY PROJECT SUMMARY

Responsible DOE Organization: Geothermal and Hydropower Technologies Division

Program: Geothermal

1. Project Title: Heber 50 MWe Geothermal Binary Cycle Plant
2. Locators: a. B&R Classification: AM-15-25-00  
b. Activity: Hydrothermal Industrialization  
c. Designation: Major Project
3. Contract No. RA50239-80-G-2
4. Contractor: San Diego Gas and Electric (SDG&E)
5. Project Description/Objectives:

This project consists of the design, construction, and operation of a plant to convert the heat content of a liquid-dominated hydrothermal geothermal reservoir into electric power. The 50 megawatt electric power plant will be used to collect statistically reliable engineering and cost data on reservoir performance and on plant construction, operation and maintenance for a five year period to determine and demonstrate predictable technical, economic, and environmental performance with acceptable risk on a commercial prototype scale. The plant will provide systems engineering data and demonstrate the readiness of state of the art technology for commercial-scale production of electric power from a high-temperature, low-to-moderate salinity hydrothermal reservoir by means of a binary energy conversion system.

The objectives of the project are:

- a. Demonstrate that state of the art conversion system technology is suitable in a commercial-scale plant for electric power generation using a specific liquid-dominated hydrothermal reservoir.
  - b. Demonstrate deliverability and longevity of the reservoir and environmental acceptability of power plant operations.
  - c. Obtain realistic cost data from which commercial production costs can be predicted with confidence.
6. Schedule of Obligations:

The total cost through completion of the DOE-Industry cost-shared Heber project is estimated to be \$126,291,000 (\$84,181,000 for design and construction, \$38,610,000 for facility operation and \$3,500,000 for supporting R&D). Based on the current cost-sharing arrangement for construction and facility operation, the total DOE share is \$64,500,000 (\$42,090,000 for construction, \$18,911,000 for facility operation, and \$3,500,000 for R&D support).

7. Activity Schedule:

The project baseline is given in Figure 1.

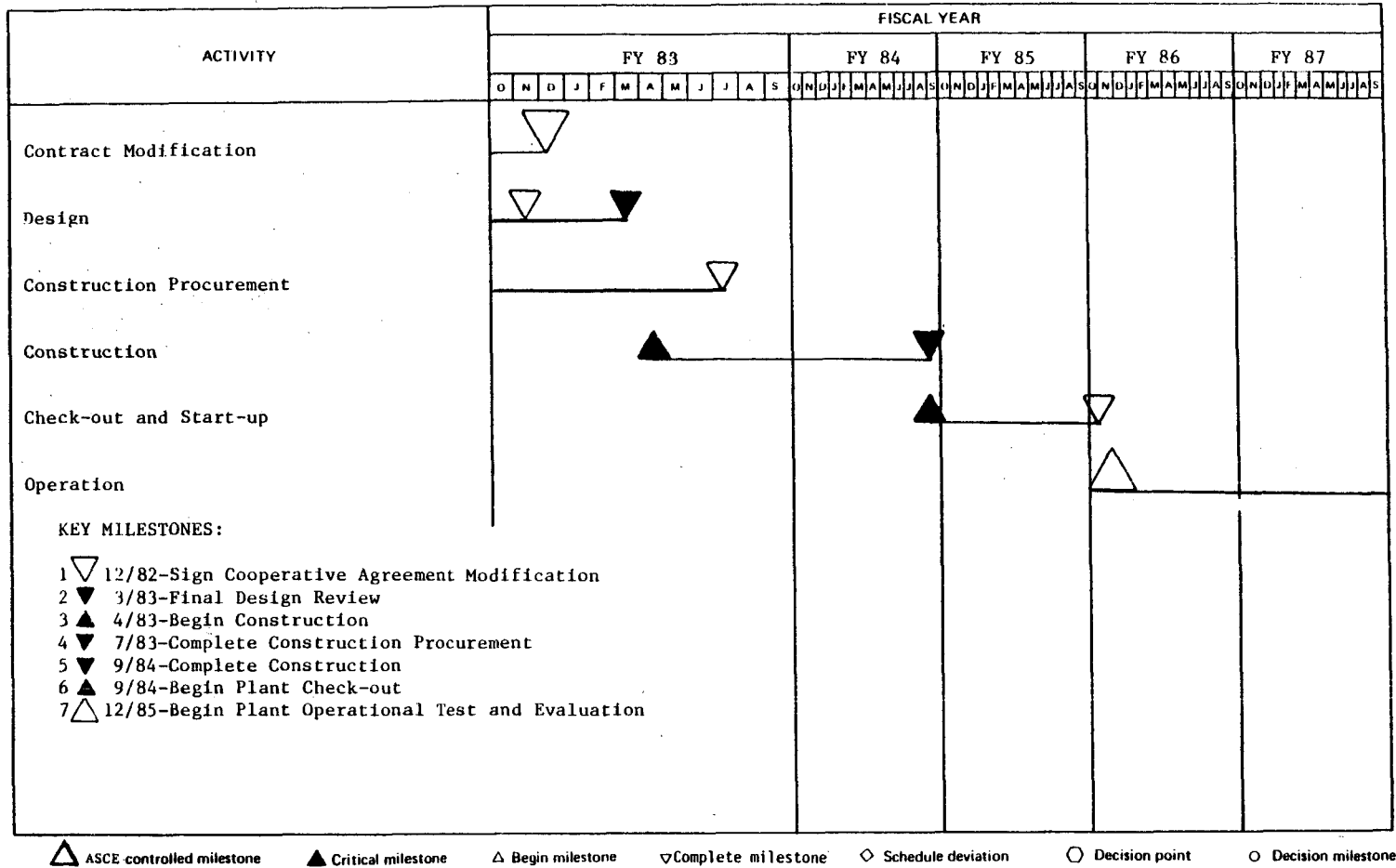
8. Schedule of DOE Costs:

The schedule of DOE costs for FY-82 and out-year for the case wherein plant construction begins in FY 1983 and facility operation begins in FY 1986 is as follows:

Heber Cash Flow Requirements (\$M)

<u>Fiscal Year</u>	<u>Amount</u>	<u>Cumulative</u>
FY-82 & Prior Year	6.7	6.7
FY-83	23.0	29.7
FY-84	20.4	50.1
FY-85	8.5	58.6
FY-86	5.1	63.7
FY-87	0.8	64.5

KEY PROJECT SUMMARY  
 HEBER 50 MWe GEOTHERMAL BINARY CYCLE PLANT



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Figure 1 - PROJECT BASELINE

## ATTACHMENT 6

GEOHERMAL PROGRAM BUDGET HISTORY  
(\$ IN MILLIONS)

<u>Sub-Program</u>	<u>FY 1980</u>	<u>FY 1981</u>	<u>Estimated BA FY 1982</u>	<u>FY 1983</u>	
				<u>BA</u>	<u>B0</u>
Hydrothermal Industrialization	\$ 70.4	\$ 57.4	\$ 5.0	\$ 56.5	\$ 37.0
Geopressure Resources	36.0	33.3	14.4	8.4	13.6
Geothermal Technology Development	41.0	49.9	20.4	15.0	23.3
o Hot Dry Rock Technology	(15.0)	(14.0)	(10.0)	( 7.5)	(10.1)
o Hydrothermal Technology	(26.0)	(35.9)	(10.4)	( 7.5)	(13.2)
Program Direction	<u>2.0</u>	<u>2.3</u>	<u>1.6</u>	<u>1.3</u>	<u>1.3</u>
Total Geothermal R&D	\$ 149.4	\$ 142.9	\$ 41.4	\$ 81.2	\$ 75.2
Geothermal Resources Development Fund	<u>0.2</u>	<u>1.3</u>	<u>2.3</u>	<u>6.9</u>	<u>1.5</u>
Total	\$ 149.4	\$ 144.2	\$ 43.7	\$ 88.1	\$ 76.7

## \*FY 1983 Availability Includes:

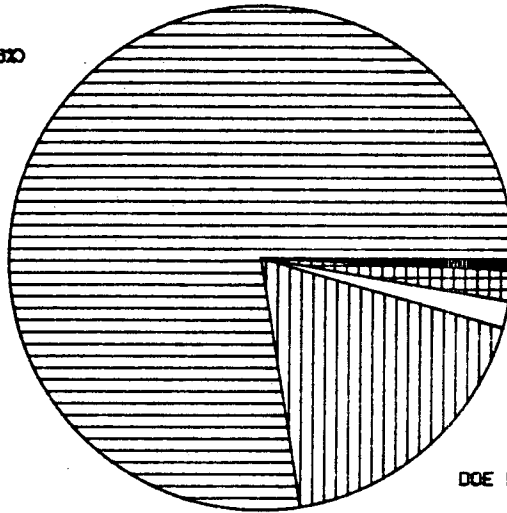
\$ 1.5M Vale (FY 82)  
 26.0M Heber (FY 82)  
 .4M Other  
 6.1M Reprogramming from other RE Programs  
 6.9M GRDF Carryover from prior years

# ALLOCATION OF FY83 FUNDS BY TYPE OF ORGANIZATION\*

(\$ IN MILLIONS)

TOTAL GEOTHERMAL: \$81.2

Industry: 63 (77.6%)

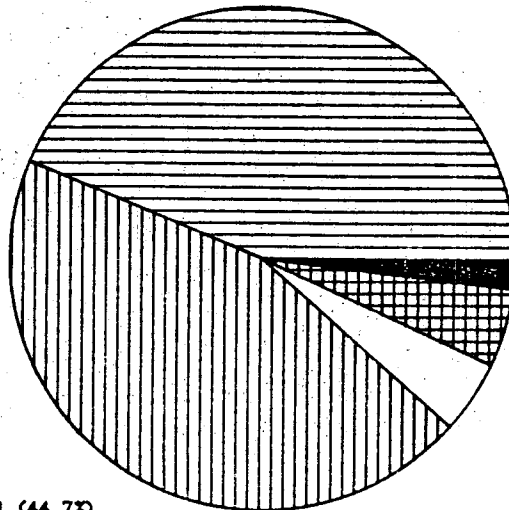


Other Federal Agencies 8.8 (10.7%)  
Others 1.8 (2.2%)  
Universities 1.4 (1.7%)

DOE Laboratories 14.6 (18.8%)

GEOTHERMAL OPERATING EXPENSES: \$32.0

Industry: 14 (43.8%)



Other Federal Agencies 8.8 (27.5%)

Others 1.8 (5.6%)

Universities 1.5 (4.7%)

DOE Laboratories 14.3 (44.7%)

\* Excludes GRDF

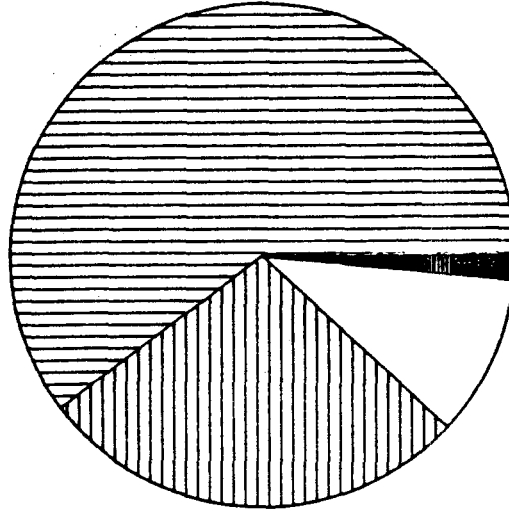
ALLOCATION OF FY83 FUNDS  
BY R&D PHASE \*

Attachment 7(b)

(\* IN MILLIONS)

TOTAL GEOTHERMAL: \$81.2

Demonstration (Heber Project): 48.8 (60.2%)



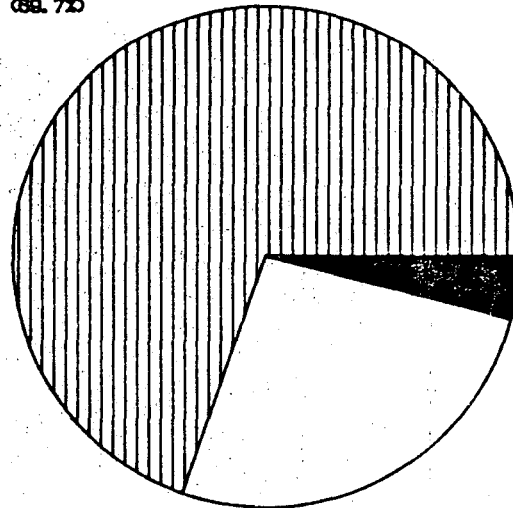
Others 1.3 (1.6%)

Engineering Developments 8.4 (10.3%)

Technology Developments 22.6 (27.8%)

GEOTHERMAL OPERATING EXPENSES: \$32.0

Technology Developments 22.3 (69.7%)



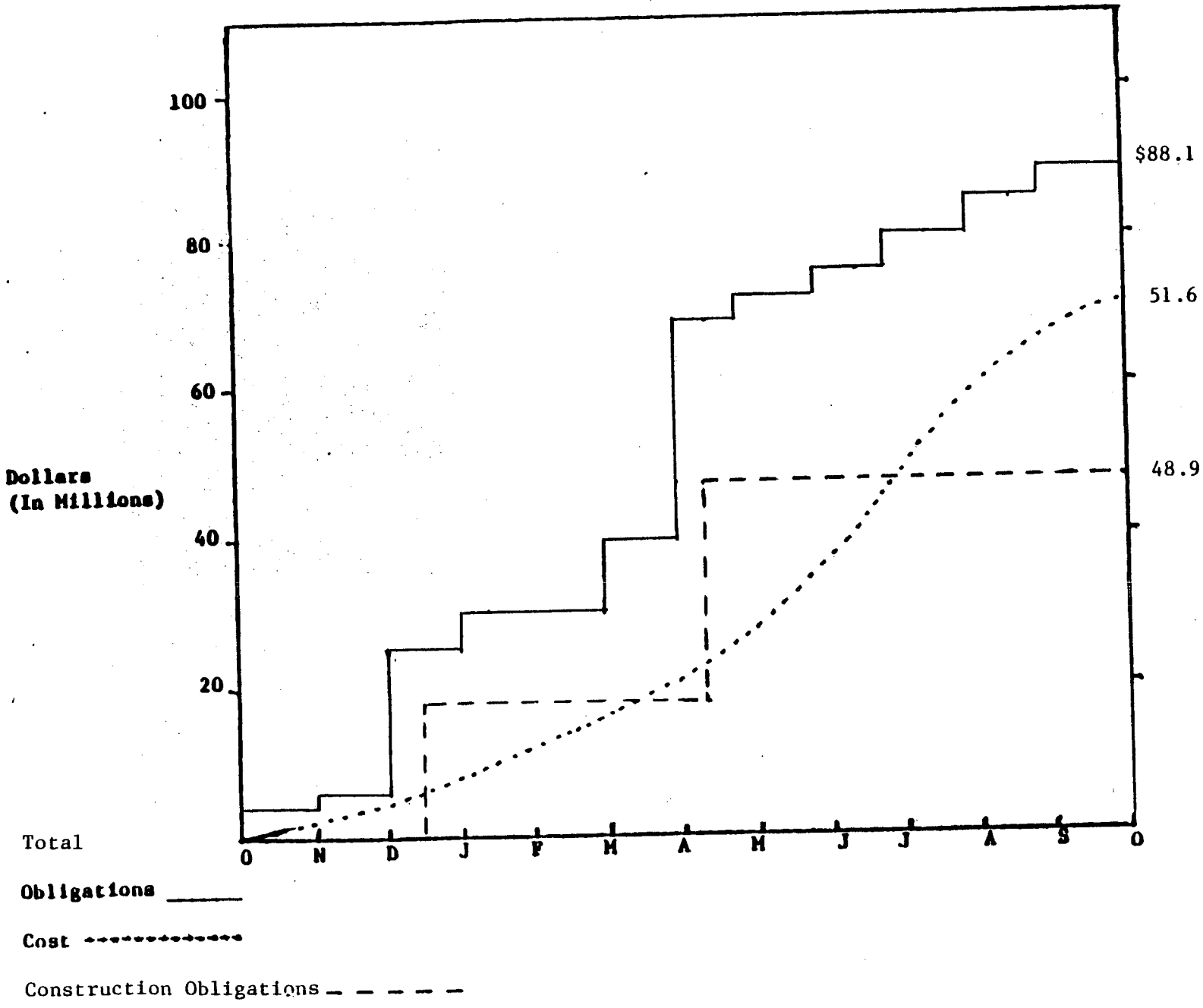
Others 1.3 (4.1%)

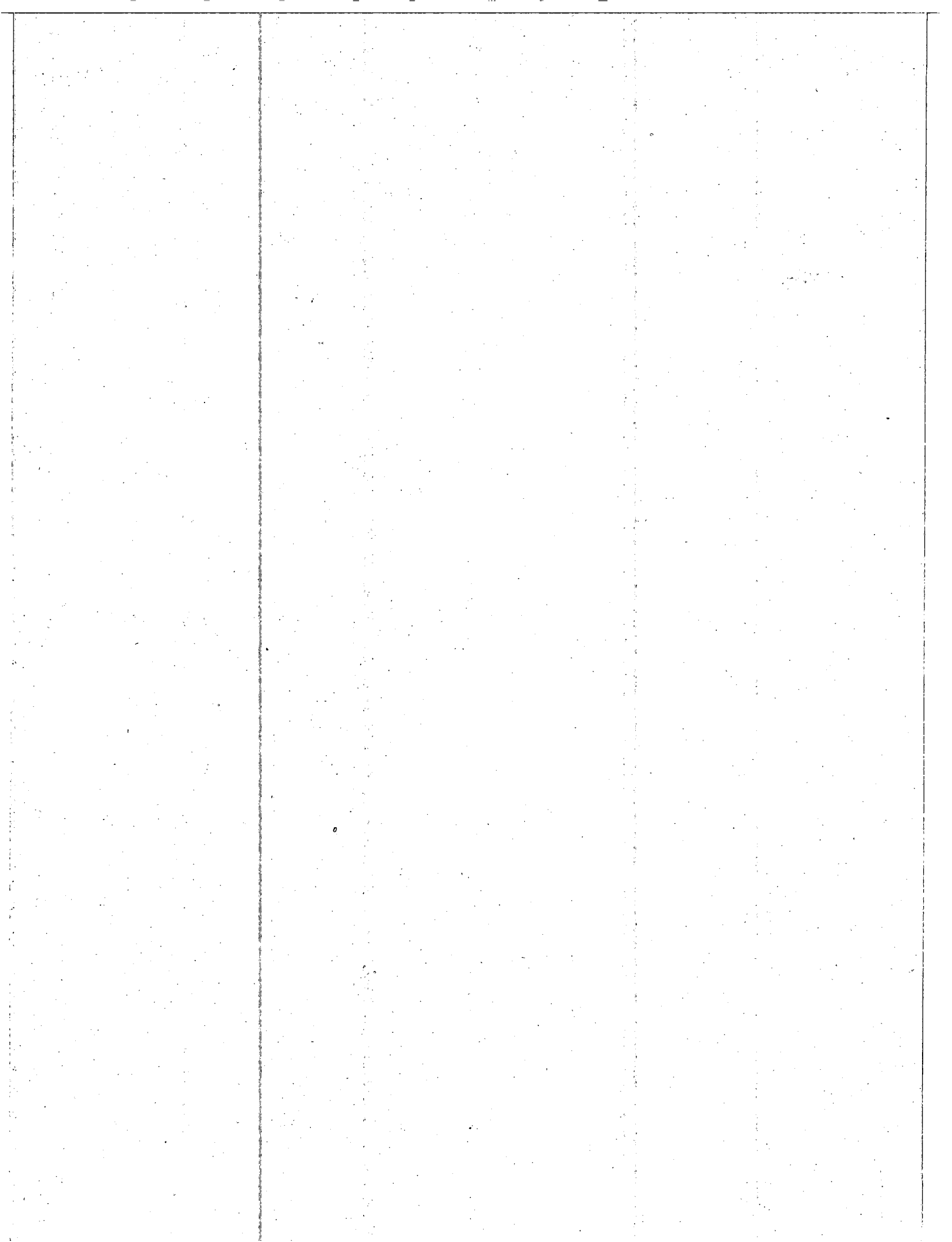
Engineering Developments 8.4 (26.3%)

\*Excludes GRDF

FY 1983 Operating and Construction Expenses  
**Planned Monthly Cumulative**

04





## FY 1983 HYDROPOWER ANNUAL OPERATING PLAN

### 1.0 PROGRAM AUTHORITIES

The Small-Scale Hydropower Development program was begun as a result of the President's energy message to Congress of April 20, 1977. The Corps of Engineers was directed to report on the potential for additional hydropower especially at small sites, and their resulting report indicated that the potential was significant but that serious constraints existed. It recommended research and demonstration to better define the engineering, economic, financial, environmental, social, and institutional constraints.

Shortly thereafter, the Energy Research and Development Administration (ERDA) initiated work in some of these areas under the Federal Non-Nuclear Energy Research and Development Act of 1974 (P.L. 93-577) which authorized a "comprehensive program in research, development, and demonstration," with "heavy emphasis ... given to those technologies which utilize renewable or essential inexhaustible energy sources."

Specific statutory authority for a "small hydro" loan program was contained in the Public Utility Regulatory Policies Act of 1978 -- "PURPA" -- (P.L. 95-617). Title IV of PURPA authorized Loans to help pay for feasibility studies of small hydro projects up to a maximum of 15 megawatts (MW) at existing dams, as well as loans to prepare license and permit applications. Appropriations of \$10 million per year for 1979, 1980 and 1981 were made for such loans to provide "front end" financing to stimulate developers. Title IV also authorized loans for construction costs, although no funds were requested or appropriated for this purpose. The project capacity ceiling for the loan program was later increased to 30 MW by P.L. 96-294. Title II of PURPA also established incentives for small hydro and other small power producers up to 80 MW which are implemented by state public utility commissions. Under these provisions, utilities are required to physically interconnect with such projects and to purchase power at the "avoided cost" of obtaining such power by other means. Further incentives were authorized by the Crude Oil Windfall Profit Tax Act of 1980 (P.L. 96-223). It provided an additional 11 percent business energy investment tax credit and liberalized the use of tax-free industrial development bonds for qualifying hydroelectric generating facilities.

## 2.0 FEDERAL AGENCIES INVOLVED IN HYDROPOWER

Several Federal agencies are directly involved in the development of hydropower. These are the Corps of Engineers (Corps), the Bureau of Reclamation (BuRec), the Federal Energy Regulatory Commission (FERC), the Tennessee Valley Authority (TVA), the Department of Agriculture (DOA) and Department of Energy (DOE).

The Corps and BuRec are the major Federal water resource development and management agencies. In conjunction with this role, they have responsibility for construction and operation of Federal hydropower facilities when such facilities are part of these projects. FERC is also a major hydropower agency, although their role is in the regulation of non-Federal development of hydropower under the Federal Power Act.

TVA has comprehensive responsibilities involving the development and operation of hydropower facilities, as well as the marketing of power within their assigned region. DOA has authority to financially assist qualifying hydropower projects in rural areas under programs administered by the Rural Electrification Administration and the Farmers Home Administration.

The most extensive DOE hydropower-related activities are exercised by the power marketing administrations, which market the power from Federal projects, constructed and operated by the Corps and BuRec. The Bonneville Power Administration (BPA) is the largest such entity. Under the Pacific Northwest Electric Power Planning and Conservation Act, BPA is also initiating major programs for energy conservation and the development of renewable energy in its region, including financial support to encourage small hydropower projects up to 50 MW.

### 3.0 HYDROPOWER DEVELOPMENT AND POTENTIAL

Hydropower has been used as a source of electrical energy for 100 years; the first U.S. plant began generating 12.5 kilowatts (kW) in 1882 in Appleton, Wisconsin. The 1980 Annual Inventory of Power Plants, put out by the Energy Information Administration, indicates that 3,209 of the 10,922 existing generating units are hydro, and they have an installed capacity of 76,407 MW. Over 11,000 MW of this capacity is for pumped storage generation. In 1977, hydropower provided about 14 percent of the installed U.S. capacity and about 10.3 percent of the electricity consumed.

Approximately one-half of the installed capacity in the U.S. has been developed by Federal agencies, and most of this development is at the larger, and in some cases, well known dams. A little over one-fourth of the installed capacity has been developed by investor-owned utilities. Slightly less than one-fourth was developed by non-Federal public agencies. This latter group includes a very broad cross-section of entities, and hydro projects range from very large (e.g., California's Shasta Dam) to very small sites developed by towns, rural co-ops, irrigation districts, etc. Less than one percent of installed capacity is owned and operated by industries.

Remaining hydropower potential is significant, but cannot be precisely quantified. This is due to the large difference between the number of sites theoretically available and those which would be practical to develop, as well as the inherent difficulty in defining this latter group. Large sites, for example, are generally the most controversial from the standpoint of competing land uses and environmental concerns. Also, many of the "best" large sites are located in remote areas. Small sites number in the thousands, and because of this large number, less is known about their individual and collective physical, environmental and economic suitability.

The Corps of Engineers has been conducting a national survey of hydropower potential. Regional inventories were released during FY 1982 and a report on the comprehensive results of their national survey will probably be released during FY 1983. The Corps had also conducted preliminary inventories of potentials prior to this national survey, some of which were financially supported by DOE.

Some of the Corps preliminary estimates identified an upper range of 50,000 sites and a potential of up to 500,000 MW. However, the present survey narrows the potential sites to 2,000 with a total potential capacity of 46,000 MW. This includes 540 undeveloped sites with a capacity of 26,500 MW and 1,400 at sites (and 19,500 MW) at existing dams, which are not presently generating power or at which the capacity could be increased.

Preliminary conclusions by the Corps are that these sites could increase the presently installed hydro capacity by nearly two-thirds and increase the average annual energy production by about 50 percent. The greatest concentration of this potential is in the Pacific Northwest, including Alaska, and the remainder is distributed throughout the country. The Corps survey is the most comprehensive survey of hydropower potential to date. Although it may not include the

smaller sites that would be of interest, for example, to many private developers, it does address those with most of the potential capacity.

Hydropower is also very significant worldwide. World Energy Conference 1980 data indicate that North America accounts for 129 gigawatts out of a world total of 363 gigawatts. The Conference estimates that North America has developed 36 percent of its potential, but that the world in total has only exploited 17 percent of potential hydropower resources.

### 3.1 REVIEW OF DOE PROGRAMS

The DOE hydroelectric development program was begun in 1977 as part of the Federal effort to help increase national energy supplies, diversify energy sources, and lessen dependence on imported oil. Small hydro was considered a prime candidate for development in that it is not only domestic and renewable, it is widely dispersed and relatively benign in terms of its environmental impacts. As such, small hydro has been the principal program focus. Hydropower is also a mature technology, and the many small sites, collectively, are capable of making a significant supply contribution in the near term.

At that time, the small hydro industry had been in a depressed state as a result of decades of decline in the use of water power for electric power generation at small sites. Hundreds--if not thousands--of small hydroelectric plants had been abandoned because of their inability to compete with low-cost oil and large central station thermal plants. As expected, however, increases in oil prices are helping to stimulate a rebirth of interest in the hydropower resource, and to reverse years of decline in our institutional and technical capability to assure a healthy hydropower industry.

The largest share of hydropower developments for several decades has been undertaken by the Federal government through the U.S. Corps of Engineers and the Bureau of Reclamation. However, previous development of the best large sites and efforts to limit direct Federal expenditures have also reduced or eliminated new starts by these agencies for several years.

The DOE program has helped stimulate a resurgence of state, local government and private interest in exploiting small hydropower. DOE has, for example, provided funds to enable the Corps, BuRec, FERC, and several states to assess the small-scale potential and to make this information available to interested developers.

Hydropower is the only energy source, other than nuclear, that is regulated at every stage of development. Large hydro projects can be expected to require as much lead time for development as nuclear projects. To be economically feasible, small hydro -- with significantly less potential payoff and probably less sophisticated developers -- requires some degree of predictability regarding developmental requirements and less lead time before a project can be brought on line.

Thus, perhaps the most important activity has been our effort -- 85% cost-shared by public and private developers -- to test, and hopefully to demonstrate, economic feasibility in the context of today's energy market. We initiated a "demonstration" or technology development program and selected 20 projects that are presently underway. These are not typical demonstrations in that the use of "proven technology" was a requirement. The projects were selected to help review the necessary public and private infrastructure, needed to sustain this

industry; to prove that small hydro can be economically feasible in a number of different areas and under differing circumstances; and to help stimulate the domestic hydropower equipment industry. Significantly, these projects are leading the way in testing, identifying and, thus, helping us develop ways to overcome current institutional and environmental constraints. The DOE share totals \$27 million out of an overall estimated cost of at least \$238 million. The 20 projects will bring 126 MW of power on line by the end of 1985.

Small hydro projects are capital-intensive, require a long lead time before revenue generation, and are only beginning to emerge as economically competitive with conventional power production. Because the front-end financial risks have been substantial, and to help stimulate development interest, Congress authorized a loan program for small hydro projects in Title IV of the Public Utility Regulatory Policies Act of 1978 (PURPA). That program authorized loans up to \$50,000 each for feasibility studies and for expenses incurred in obtaining a Federal Energy Regulatory Commission (FERC) license and other required permits. Further, loans may be cancelled if a project is found not to be feasible. Otherwise, repayment must be made over ten years, beginning four years after the loan is made. We are now monitoring a total of 160 of these loans which were approved before the program was terminated in 1981.

We believe that significant progress has also been made in the mitigation of restrictive Federal and state laws, procedures and environmental requirements. Through research contracts with the Johns Hopkins University and the Energy Law Institute (ELI), legal and institutional impediments have been identified and solutions recommended. Utilizing the findings of the studies, we have funded the National Conference of State Legislatures to provide technical support for state legislatures in implementing legislation and procedures to minimize regulatory and other barriers. We have also worked closely with FERC to improve and expedite the Federal permitting and licensing process.

In most areas of the country, low rates paid for electricity produced by small-scale facilities have added to the financial risk of development. However, FERC, pursuant to Title II of PURPA, has provided what we believe will be a significant boost for the reestablishment of the small hydro industry by developing a sound procedure for states to follow in determining attractive rates. Regulations have been published requiring each state public utility commission to establish rates using the avoided or marginal cost concept. The ELI, with funding and direction from DOE, has provided technical assistance to the state's PUCs in this effort. When such rates are in place, they should serve as an important aid in helping small power producers negotiate favorable power-purchase contracts with their local public utilities.

In the environmental area, the cost of fish transport facilities, for example, when added to the cost of retrofitting dams for power generation, could make projects economically infeasible. Meeting requested minimum streamflow requirements below the projects could have a similar impact. DOE is funding research to provide technical and cost guidance for developers and to resolve issues between FERC and the U.S. Fish and Wildlife Service on minimum streamflow requirements.

Hydropower is a mature technology, except for retrofit techniques. DOE research and development efforts, outside the environmental area, have been limited to a few conceptual designs and in some cases model and field tests, that have been cost-shared with industry. They have focused on cost-reduction techniques and retrofit technology.

The rationale for continued DOE involvement in these cases lies in the lack of independent U.S. industry activity, sufficient to maintain and service the U.S. technology base. (One-third of operating electric generating units and one-eighth of the generating capacity in the U.S. are hydro.) DOE involvement has also helped stimulate U.S. industry attention to the small hydro potential, which in general, requires more economic technology for development.

A current Electric Power Research Institute (EPRI) study identifies hydropower R&D needs in the following areas: (1) forced outages, (2) frequency of scheduled outages, (3) reliability of new equipment, (4) environmental impact, (5) dam safety and monitoring, (6) small hydro development, (7) hydro output optimization, and (8) operating procedures. EPRI hopes to undertake R&D in most or all of these areas and wants to cooperate with specific utilities, industries, and DOE to the extent possible. Items 4 and 6 above are the least likely to receive independent support from utilities and industry, and are the areas receiving the primary attention by DOE.

We believe small hydropower is particularly appropriate for non-Federal development and that the states need to exert a leadership role if the development potential is to be realized. State- and developer-related activities of the program were implemented in the field by the DOE regional offices. Through these efforts, we have encouraged the states to simplify their procedures, identify potential sites and, in turn, encourage developers to undertake projects.

## 4.0 PROGRAM STATUS

### 4.1 TECHNOLOGY DEVELOPMENT PROJECTS

This program activity is well underway. Eight projects and 45 MW are on line, and the remaining 12 projects are under construction or in the licensing stage. The total remaining Federal share for the uncompleted projects was provided in the revised Presidential budget for FY 1981. The Federal cost is \$27 million out of an approximate total cost of \$238 million for the 20 projects. Most projects are expected to be on line by the end of 1985, providing a total power-on-line of 126 MW.

All of the projects, including those still in the licensing stage, are presently serving as good test cases of current development barriers. Regular reports from the developers address financial, regulatory and environmental barriers, as well as technical barriers, and the developers are required to continue reporting on their development experience for two years after the projects go on-line. Performance testing of different type turbines at completed technology development projects will be conducted. In FY 1983 and remaining years, we will be focusing on monitoring the progress of these projects and evaluating their data. Dissemination of the "lessons learned" to other potential developers and regulatory agencies will be assured through technology transfer with EPRI. One staff year of Idaho National Engineering Laboratory (INEL) support will be provided for these activities.

### 4.2 ENGINEERING DEVELOPMENT

The objective of this program activity has been to reduce the costs of retrofitting existing dams and of developing ultra low-head sites. Hydropower technology is mature insofar as new dam construction is involved. Retrofit technology has not reached a similar degree of maturity. Similarly, considerable cost reductions are required before most of the thousands of ultra low-head sites will be feasible to develop. Concepts and techniques investigated include the use of pumps as turbines, water and electrical control systems, new turbines and new materials.

FY 82 activities have included the initiation of two projects which will result in field tests of the Schneider engine and the marine thruster, the completion of the Micro-Hydro Manual for projects with capabilities of less than 100 KW, the completion of a report summarizing the experience of using pumps as turbines, and performance testing of one completed technology development project.

In FY 82, DOE funded a project on prefabricated plant systems which includes a siphon penstock, a pump used as a turbine and automatic controls. EPRI has funded feasibility studies and site case studies on these topics and will continue to actively participate in the project, including a sharing of costs. The project is directed at field testing of concepts and model tests already performed by DOE.

In FY 83, DOE will initiate projects leading to field tests of a variable speed generator. The project uses a variable speed generator that will be designed, built, and tested to produce synchronous 60 Hz power from a turbine

operating at variable speeds from a variable head water supply. The cross-flow turbine field test will confirm that cost-effective turbines can be produced from concepts developed from earlier projects by unsophisticated machine shops and contractors.

#### 4.3 ENVIRONMENTAL R&D

Most of the environmental constraints which were identified at the outset of the small hydro program have been addressed and reports published. FY 1982 efforts consisted of field testing of methodologies for defining minimum streamflow requirements for fish productivity.

This minimum streamflow issue surfaced in 1980 during the detailed engineering design phase of the Bolton Falls, Vermont, technology development project. It rapidly became a formidable obstacle, threatening to stop this project and slow or stop the rapidly growing interest in redeveloping hundreds of existing small dams in the Northeast and perhaps the entire country. In the Bolton Falls case, the U.S. Fish and Wildlife Service (FWS) recommended maintenance of minimum flows in the stream below the dam that were several orders of magnitude greater than had been previously thought necessary by the developer. This meant significantly greater capital costs for the Bolton Falls project in order to provide flexibility to operate under a wider range of flows, as well as a reduction in the amount of power which could be produced. In other words, it threatened a dramatic reversal in the economic feasibility of the project.

The FWS is required by statute to comment on all such projects. The Federal Energy Regulatory Commission (FERC) makes the final (licensing) decision in such cases and was doubtful as to the basis for the FWS position. It also considers the views of the states and the developers involved. However, that agency indicated it would need a scientific or other sound basis for setting flow requirements less than recommended by FWS.

The ODE minimum flow R&D effort is directed to provide a scientific basis for FERC licensing decisions, including cost-benefit tradeoffs for flow versus fish productivity. FERC, FWS and other interested agencies have been involved in developing the DOE research effort, and FERC has been acting as a technical advisor. Paper studies were completed in FY 1982. DOE will continue instream flow R&D in FY 1983, largely to extend and extrapolate the work done in FY 1982 to other regions in the U.S.

Mortality resulting from turbine passage can be a major impact to downstream migrating fish. Little is known about mortality resulting from newer turbine designs currently being installed at hydropower sites. Research will be conducted in FY 1983 to assess these effects and develop mitigation methods.

#### 4.4 FEASIBILITY STUDY LOAN PROGRAM

The loan program was established under PURPA. The first loan was awarded in April 1980, and 411 applications had been screened and accepted and 160 loan agreements made by the end of FY 1981 when the loan program was terminated. The 160 loans include 139 loans for feasibility studies and 21 loans to cover licensing costs.

Under PURPA, there is a formal monitoring period of up to 10 years, although most activity will occur during the first four years. During this time, applicants may request cancellation, which under PURPA must be approved by DOE, if the projects are shown as not feasible for any reason. Experience to date suggests that 30 to 40 percent will request cancellation.

In order to minimize program expenditures, most (over 20 staff years) of the day-to-day administrative support provided by INEL was terminated soon after the awarding of loans was suspended, and only three INEL staff years have been maintained for the required monitoring. The Idaho Operations (ID) unit responsible for program management was also discontinued during FY 1981, and the loan program has been reassigned to the organizational unit which handles the technology development and engineering development programs, described above. Monitoring of about 100 loans was completed in FY 1982. During FY 1983, all formal monitoring of licensing and feasibility study loans will be completed, and average INEL support will be reduced to one staff year.

#### 4.5 GENERAL AND STATE ASSISTANCE

Most of the work in this activity involves completion of projects funded prior to FY 1982. Specifically, these include: (1) administering and closing out contracts implemented by the former DOE regional offices, largely to provide support for state initiatives; (2) phasing out the technical assistance to state public utility commissions on the implementation of PURPA incentives, provided by the Energy Law Institute; and (3) phasing out the technical/legal assistance to state legislatures, provided by the National Conference of State Legislatures (NCSL). These activities have been largely completed.

A small amount of additional funding was also used in FY 1982 to package the "lessons learned" from the ELI and NCSL efforts for use by other states and to update the previously published small hydro private financing guide.

#### 4.6 TECHNOLOGY TRANSFER

All DOE projects have involved arrangements for submitting appropriate reports for printing. Since the decision during FY 1981 to phase out the small hydro-power program, additional consideration is being given to appropriate mechanisms for getting this information to the developers and others for which it was intended. The technology development program is a particular challenge, since the lessons to be learned cover many topical areas and will extend a few more years into the future.

Other organizations with an active interest in hydropower are being involved in DOE activities, and it is expected that they will participate formally and informally in technology transfer efforts. FERC, for example, is a primary beneficiary from the DOE environmental R&D, and it is serving as the lead technical advisor to DOE on the minimum flow R&D. This will also assist transfer efforts, although FERC does not want to compromise its regulatory role by "promoting" the use of such information.

The Electric Power Research Institute is very interested in assuring that DOE information is made available to their constituency (mostly utilities). In FY 1982, DOE focused most of its effort on initiating and funding a joint

technology transfer project with EPRI. This project is now underway. DOE will continue to cooperate with EPRI in FY 1983, and will provide two staff years of INEL support for these activities.

## 5.0 PROGRAM STRUCTURE

The Hydroelectric Resource Development Program is centrally managed by the Small-Scale Hydropower Branch, Geothermal and Hydropower Technologies Division. Technical day-to-day program operations for the demonstration projects, engineering development and loan program are carried out by the Idaho Operations Office and the Idaho National Engineering Laboratory at Idaho Falls. Environmental R&D and field testing is implemented by the Oak Ridge National Laboratory (ORNL). The following chart illustrates the hydropower program organization. All hydro program activities are carried out under the Small-Scale Hydropower Development line item.

Program milestones and budget history are illustrated in Tables I and II. Key activities are shown in Table III.

HYDROPOWER

HQ-SMALL SCALE HYDROPOWER BRANCH

o PROGRAM DIRECTION

ORNL

- o ENVIRONMENTAL RESEARCH
  - DEVELOPING GUIDANCE TO ASSIST REGULATORY AGENCIES & DEVELOPERS

IDO & INEL

- o ULTRA LOW HEAD R&D
- o TECHNOLOGY DEVELOPMENT PROJECTS
  - MONITORING 20 PROJECTS PREVIOUSLY FUNDED
- o TECHNOLOGY SUPPORT
  - TECHNOLOGY TRANSFER
  - TECHNICAL DATA BASE
- o LOAN PROGRAM
  - COMPLETE CLOSE-OUT MONITORING
  - PROCESS CANCELLATION REQUESTS

EPRI

- o COST-SHARED TECHNOLOGY TRANSFER & R&D PROJECTS

TABLE I

## DOE Small Hydropower Program

Technology Development

December 8, 1982

Project name	Total cost	DOE cost*	FY83	FY84	FY85	FY86	FY87	
Turlock	4,526,887 (Actual)	719,000	▲					
Good Year Lake (Stapenhorst)	1,772,301 (Actual)	245,000	▲					
Sawmill (James-New Hampshire)	4,600,000 (Actual)	1,022,000	▲					
Fries Textile (Riegel)	1,300,000 (Actual)	224,824	▲					
Salt River	2,600,000 (Actual)	357,702	▲					
Garvin Falls (Pub.Ser. Co. of NH)	6,165,000	924,750		▲				
Shawmut (Central Maine)	5,721,350 (Actual)	850,000		▲				
Idaho Falls	49,974,036	7,300,000				▲		
Gonzales	1,973,000	295,000	△		▲			
Upper Dam (Spokane)	11,735,000	1,760,250		△		▲		
Upper Mechanicville (NYSE&G)	25,640,000	2,500,000		△		▲		
Garland Canal (Shoshone)	2,967,800	445,170				▲		
Elk Rapids (Antrim County)	679,000	164,250	△	△			▲	
Carlyle	7,836,897	1,175,250	△		△		▲	
Cherokee Falls (Broad River)	7,017,759	1,052,664	△		△		▲	
Jackson Bluff (Tallahassee)	11,671,200 ●	1,750,680		△		▲		
Boott Mills	27,959,000	2,197,000	△		△		▲	
Great Falls (City of Paterson)	8,800,000	1,320,000	△		△		▲	
Flat Rock (Penn. Hydro)	6,234,000	935,100	Schedule unknown due to problems					
Bolton Falls (Green Mountain)	5,890,050	1,467,513	Schedule unknown due to problems					

- △ Construction begun
- △ Power on-line
- ▲ Completion of O&M period and submission of final report

● Funding provided prior to FY83

## DOE Small Hydropower Program

### Engineering Development Projects

December 8, 1982

Project name	Total cost	DOE cost	FY83	FY84	FY85	FY86	FY87
Pumps as Turbines Experience Profile	\$120K	\$120K	▲				
Microhydropower Handbook	\$250K	\$250K	▲				
Marine Thruster	\$698K	\$247K	△	△	▲		
Schneider Engine	\$568K	\$453K	△	△	▲		
Prefabricated Plant System	\$4,000K	\$790K	△		△	△	▲
Variable Speed Generator	\$1,500K	(FY-83) \$400K		△	△	△	▲
Crossflow Turbine	\$1,000K	(FY-83) \$350K		△	△	△	▲

Milestone references: △ Begin contract      △ Complete construction      △ Complete testing      ▲ Final Report

### Environmental Research

Project name	Total cost	DOE cost	FY83	FY84	FY85	FY86	FY87
Minimum Streamflow Research	\$800K	\$800K	△	△			
Turbine Mortality Research	\$200K	\$200K		△			

Milestone references: △ Interim report      △ Final report

### Technology Transfer

Project name	Total cost	DOE cost	FY83	FY84	FY85	FY86	FY87
Lessons learned	TBD*	\$500K	△	△	△	▲	

Milestone References: △ Begin contract      △ Feasibility Studies & Licensing Activities Summary Documents  
 △ Demonstration Projects Summary Document      ▲ Recommendations Manual (final report)

\* A joint DOE/EPRI project; EPRI funding TBD

TABLE II

HYDROPOWER BUDGET HISTORY

BA IN MILLIONS

	<u>FY 77</u>	<u>FY 78</u>	<u>FY 79</u>	<u>FY 80</u>	<u>FY 81</u> <sup>1/</sup>	<u>FY 82</u> <sup>1/</sup>	<u>FY 83</u>
SMALL HYDROPOWER DEVELOPMENT							
TECHNOLOGY DEVELOPMENT PROJECTS		6.0	9.8	8.1	3.7	0	0
TECHNOLOGY SUPPORT AND ENGR. DEVELOPMENT	1.6	3.8	4.9	0.8	0.9	2.1	1.2
LEGAL, INSTITUTIONAL AND ENVIRONMENTAL RESEARCH		1.2	1.5	1.2	0.9	0.7	0.6
REGIONAL ACTIVITIES		0	1.8	1.9	1.3	0	0
SUBTOTAL	<u>1.6</u>	<u>11.0</u>	<u>18.0</u>	<u>12.0</u>	<u>6.8</u>	<u>2.8</u>	<u>1.8</u>
LOANS	0	0	0.6	4.0	4.2	-	-
PROGRAM DIRECTION	0	0	0.4	0.6	0.8	0.2	0.2
TOTAL BA	<u>1.6</u>	<u>11.0</u>	<u>19.0</u>	<u>16.0</u>	<u>11.8</u>	<u>3.0</u>	<u>2.0</u>






1/ A TOTAL OF \$1M OF FY 82 AND PRIOR YEAR FUNDS WERE PROPOSED FOR RE-PROGRAMMING FOR HEBER.

TABLE III

KEY ACTIVITY SCHEDULE

DIVISION: Geothermal and Hydropower Technologies  
 DIVISION DIRECTOR: John E. Mock

OBJECTIVES/ACTIVITIES	\$ RESOURCES NEW FY 83 BA + UNOBLIGATED CARRYOVER	FISCAL YEAR 1983				FISCAL YEAR 1984				
		1st QTR	2nd QTR	3rd QTR	4th QTR	1st QTR	2nd QTR	3rd QTR	4th QTR	
<b>F. SMALL SCALE HYDROPOWER</b>	\$2,000,000									
1. <u>Project Monitoring and Support</u>										
2. <u>Demonstration Projects</u>					1		2	3	4	
- Bring 5 Additional Demonstration Projects On-line for a New Total of 13 Projects (76MWe) (1) Gonzales, TX (2) Spokane, WA (3) Upper Mechanicsville, N.Y. (4) Garland Canal, N.Y. (5) Elk Rapids, MI					▼		▼	▼	▼	5
3. <u>Environmental Research</u>										
- Field Tests and R&D for Minimum Stream Flow Requirements					Interim Report	▼		Final Report	▼	
4. <u>Engineering Development</u>										
- Schneider Engine and Marine Thruster Projects					Schneider Engine Installation	▲		Marine Thruster	▼	Schneider Engine
- DOE-EPRI Technology Transfer						Reliability Report	▼		Demo Projects Report	▼
5. <u>Loan Program</u>										
- Monitoring of Remaining Loans										▼

 ASCE-Controlled Milestone    
  DOE-Controlled Milestone    
  Begin Milestone    
  Complete Milestone    
  Decision Milestone