# *MANAGEMENT-BY-OBJECTIVES PLAN*

# *FY 1991*

GEOTHERMAL DIVISION

U.S. DEPARTMENT OF ENERGY

June 5, 1991

## DISCLAIMER

# I. INTRODUCTION

# I. INTRODUCTION

The Geothermal Division of the Department of Energy employs management by objectives in the administration of its research program. Program objectives are defined on three separate levels as illustrated in Figure I. Level I objectives are associated with geothermal resource categories and provide a target for decreasing the total cost of electric power generated from a particular resource category. Level II objectives address incremental improvements in the cost and/or performance of major system components which comprise a geothermal power project within a geothermal resource category. The third level objectives identify individual research activity targets for improvements in cost, efficiency and dependability of related materials, tools, equipment, tests and processes.

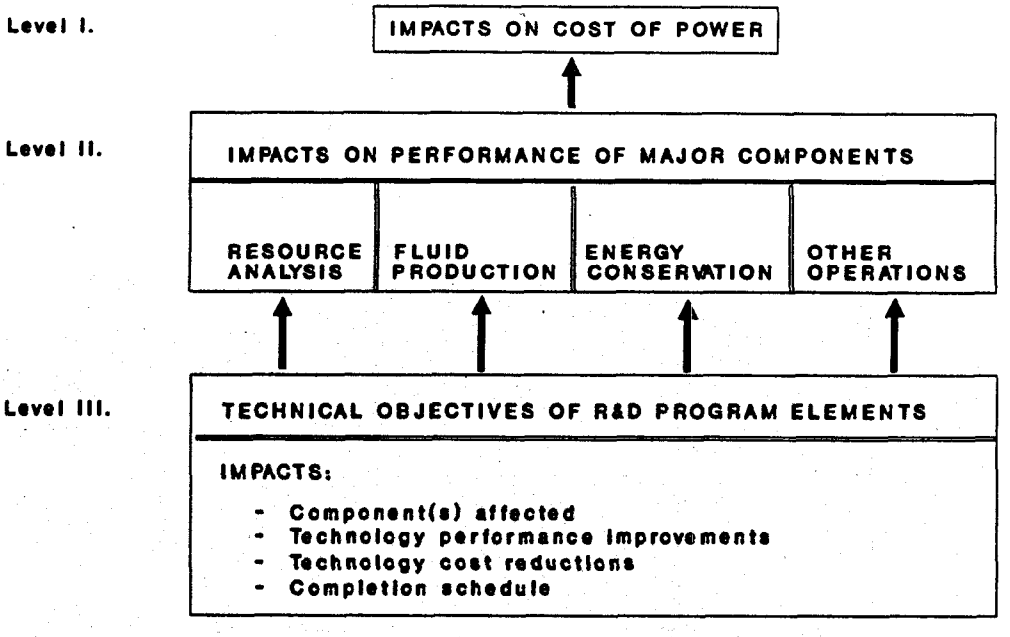



**Figure 1. Geothermal Research Objectives Heirarchy**

The achievement of Level I objectives depends on the achievement of the Level II and Level III objectives. The Level III objectives and associated research activities are the most dynamic part of each year's program and therefore require annual updates. The purpose of this document is to present the research objectives and related activities as they apply to Fiscal Year 1991 with a look ahead to Fiscal Year 1992.

At present, the Level I objectives for each resource type are:

- Hydrothermal - The overall objective of the program is to reduce the cost of electric power from liquid-dominated, moderate-temperature hydrothermal resources to 3-7 cents per kilowatt-hour (KWH) by 1997. The compares with a cost range of 4-18 cents/KWH for hydrothermal electric power as of 1986.
- Geopressured-Geothermal - The objective is to provide sufficient information about the geopressured geothermal resource to enable industry to decide whether to proceed with commercialization.
- Hot Dry Rock - The objective of the hot dry rock R&D is to provide the technology needed by industry to make informed decisions about commercializing the resource.
- Magma - The objective of magma has been refocused to address the potential hydrothermal resources in the Long Valley area.

The level II objectives outlined in a 1989 document titled, "Programmatic Objectives of the Geothermal Technology Division, Volume I," have since been modified by a change in policy to focus R&D efforts on near-term projects of high priority to industry.

The Level III objectives are defined in Section II of this document, and the individual milestones associated with the Level III objectives are presented in the extended table.

## PROGRAM STRATEGY

The goal of the geothermal research program is to foster the development of the U.S. geothermal industry and thus contribute to national energy independence. The overall strategy being implemented toward achievement of this goal is to determine what technologies are needed, sponsor research and development projects that will produce them, and assure the transfer of the new technology to the geothermal industry.

The assessment of technological needs and the formation of plans to meet them involves close liaison between DOE, the geothermal industry and leading technical experts. The process addresses current and completed R&D projects as well as setting direction for future projects and involves industry leaders, technical experts, national laboratory staff and management personnel from DOE headquarters and field offices.

The approved research and development plans are executed, within financial and legal constraints, under the direction of the Geothermal Division, with active day-to-day management responsibility delegated to field offices. The program exercises its legal obligation to utilize appropriated funds to sponsor, monitor, and manage research and development activities required to maintain program goals. The program achieves results by accessing a broad range of scientific talent in industry, DOE labs, and universities.

An essential element of the program strategy is the rapid transfer of newly developed technology to industry. Research results are documented and

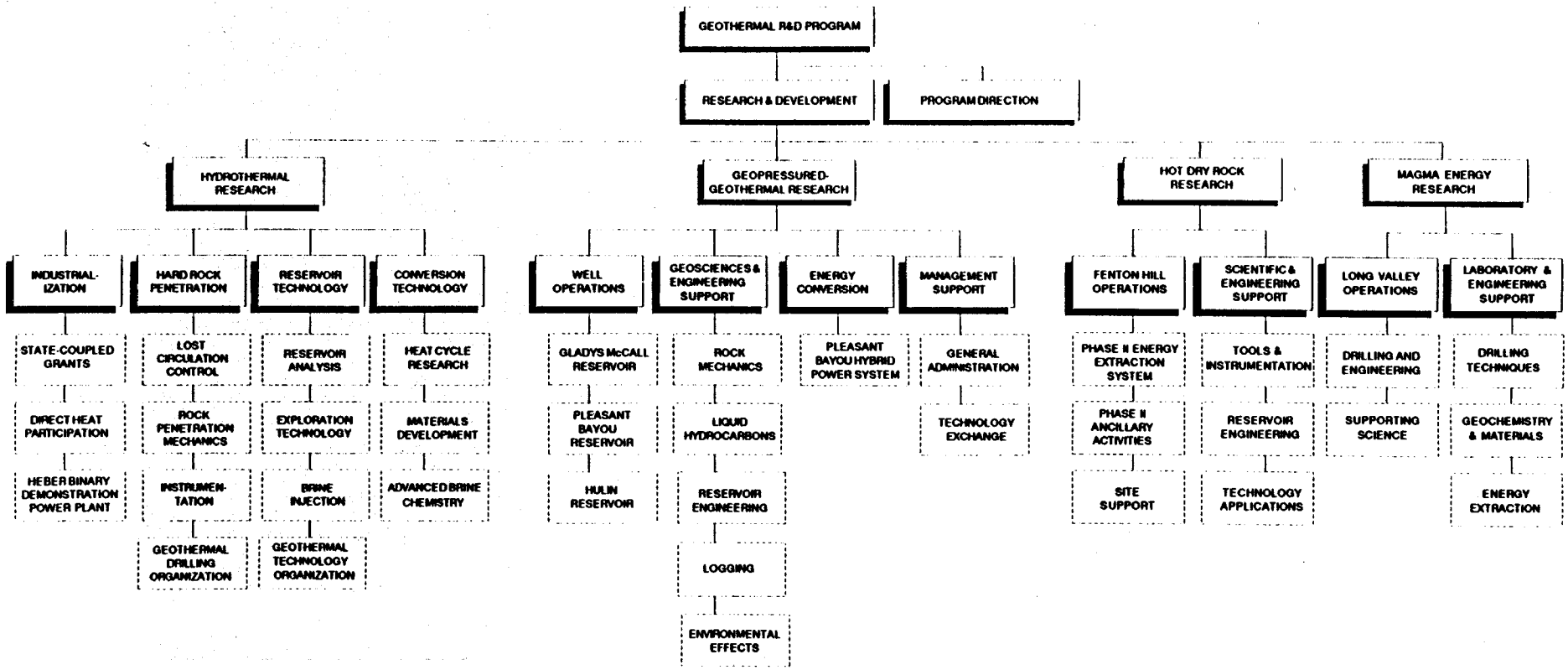
preserved and then disseminated to the proper technical and industrial communities through workshops, conferences and publication in industry technical and trade journals. One of the most effective and desirable means to technology transfer is the direct participation of industrial concerns in the research. This may be accomplished through contracting with them as performers, or through cost-sharing arrangements that may include the acquisition of proprietary rights in the research.

## PROGRAM OVERVIEW

The Geothermal R&D Program contains four categories that parallel the resource types: Hydrothermal, Geopressured-Geothermal, Hot Dry Rock, and Magma. These categories, as shown in Figure 2, are further subdivided into tasks, projects, and activities. Planned resources for FY 1991 are shown in Table 1.

The Hydrothermal category embraces four interrelated research tasks: Industrialization, Reservoir Technology, Hard Rock Penetration, and Conversion Technology. The Industrialization task provides an opportunity for individual states to cooperatively assist in hydrothermal resource assessments and direct heat projects. The task also provides cooperative research with industry to develop geothermal binary cycle technology. The Reservoir Technology task supports research that will improve geophysical interpretation and modeling techniques; improve injectivity and extend well life; and cooperatively fund industry research through the Geothermal Technology Organization. The Hard Rock Penetration task improves lost circulation methodologies and materials;

# Figure 2
# PROGRAM HIERARCHY
# GEOTHERMAL R&D



advances rock penetration mechanics; and improves downhole instrumentation. This task also includes priority research cost-shared with industry through the auspices of, an industrial consortium, the Geothermal Drilling Organization. The Conversion Technology task improves geofluid efficiencies in binary plants; reduces cooling water makeup requirements; develops advanced geothermal materials; advances an understanding of the thermodynamic behavior of geothermal brines; and develops techniques for handling residual waste.

Geopressured-Geothermal research includes four tasks: Well Operations, Geoscience and Engineering Support, Energy Conversion, and Management Support. The Well Operations task verifies the reliability of geopressured-geothermal reservoirs through long-term well testing.

The Geoscience and Engineering Support task involves the analysis of well test data and development of predictive models for reservoir performance. The Energy Conversion task supports the decommissioning of the Pleasant Bayou Hybrid Power System in Texas, which used geopressured brines to produce electric power -- the first plant of its kind in the world. The Management Support task provides general administration and technology exchange activities.

The Hot Dry Rock category is comprised of three tasks: Fenton Hill Operations, Scientific and Engineering Support, and the Nutrioso project. The Fenton Hill Operation task supports the energy extraction system, along with necessary ancillary activities, at the Fenton Hill, New Mexico, Hot Dry Rock site. The Scientific and Engineering task involves seismic and geochemical investigations, reservoir engineering work, and other technology support

activities. The Nutrioso project is just beginning. The project is designed to assist the State of Arizona in developing the hot dry rock resource for electricity production at Nutrioso, Arizona.

Long Valley Experimental Well research is also divided into two tasks: Long Valley Operations and Laboratory and Engineering Support. The Long Valley Operations task supports the drilling and engineering at Long Valley caldera in California. The Laboratory and Engineering Support task encompasses research on drilling techniques, geochemistry and materials, and energy extraction.

# II. GEOTHERMAL PROJECT OBJECTIVES FOR FISCAL YEAR 1991

# II. GEOTHERMAL PROJECT OBJECTIVES FOR FISCAL YEAR 1991

The following section details the project objectives, taken from the individual Laboratory annual operating plans, for the FY 1991 research year. These objectives set the standards which are pursued throughout the year. The objectives collectively support the level III objectives that ultimately govern the overall level I objectives of the entire research program.

## HYDROTHERMAL RESEARCH

1. Industrialization

   a. State Coupled Grants

      - Increase knowledge of low- to moderate-temperature (less than 150°C) geothermal resources by funding cost-shared, state-oriented research and development of geothermal energy.

   b. Direct Heat Participation

      - Encourage the direct use of geothermal resources by providing technical assistance to business and individuals for geothermal resource development using low- to moderate-temperature brines.

      - Encourage the use of geothermal heat pumps as part of electric utilities' integrated resource planning.

   c. Heber Binary Demonstration Power Plant

      - Facilitate negotiations between the resource owners, plant owners, and prospective buyers with the expectation that the plant will be sold.

   d. Geothermal Test Facility

      - Dispose of barrels of possibly hazardous materials at the Geothermal Test Facility.

- Characterize the pond sludge at the Geothermal Test Facility.
- Transfer the Geothermal Test Facility to industry.

e. Boise, Idaho Project

- Analyze reservoir and improve the Boise district heating system.

2. Reservoir Technology

a. Reservoir Analysis

- Improve production well citing accuracy for both reservoir identification and confirmation wells.
- Decrease the uncertainty associated with long-term decline predictions of temperature, pressure, and flow rate.

b. Exploration Technology

- Improve methods of detecting and confirming reservoirs in the Cascades and other volcanic areas.
- Increase the success rate of citing exploration wells.

c. Brine Injection

- Developed methods of citing injection wells for the greatest efficiency in maintaining reservoir pressure and productivity.

d. Geothermal Technology Organization

- Cost-share research with industry to allow access to operating fields where new methods and equipment can be tested.

3. Hard Rock Penetration

a. Lost Circulation Control

- Reduce cost associated with lost circulation episodes.

b. Rock Penetration Mechanics

- Develop components for high temperature drilling/coring systems.

- Reduce cost of deep wells and directionally drilled wells.

c. Instrumentation

- Improve well citing accuracy through better identification of fractures.
- Decrease cost of drilling production-related geothermal wells through more accurate completion-zone citing.
- Decrease the uncertainties in measurements of downhole and well head temperature, pressure, and flow measurements.

d. Geothermal Drilling Organization

- Develop and transfer other related technology to affect an additional reduction in well costs.

4. Conversion Technology

a. Heat Cycle Research

- Increase net geothermal fluid effectiveness of binary plants by 20 percent by 1992.
- Increase net geothermal fluid effectiveness of binary plants by 8 percent by 1992 through the utilization of supersaturated vapor turbine expansions.
- Reduce heat rejection system cooling water make-up requirements for geothermal power plants, while retaining performance comparable with conventional wet cooling.

b. Materials Development

- Reduce costs associated with lost circulation episodes.
- Develop well-cementing materials with a service lifetime of 30 years at 400°-600°C.
- Develop a corrosion-resistant and low-fouling heat exchanger tube costing no more than three times as much as carbon steel tubes.

c. Advanced Brine Chemistry

- Reduce geothermal production well maintenance costs related to scale deposition.
- Reduce geothermal field surface equipment costs related to scale deposition.
- Reduce geothermal power plant maintenance and equipment replacement costs related to scale deposition.
- Reduce costs of environmentally safe surface disposal of sludge from geothermal brines.

## GEOPRESSURED-GEOTHERMAL RESEARCH

1. Well Operations

a. Gladys McCall Reservoir

- Determine the drive mechanism(s) in the geopressured-geothermal reservoir and the reservoir's long-term production capacity.

b. Pleasant Bayou Reservoir

- Determine reservoir's long-term production capacity.
- Reduce the cost of production of geopressured-geothermal energy through process automation, control of scale and corrosion, and increase experience in surface handling facilities.

c. Hulin Reservoir

- Determine reservoir's energy content and production capacity.
- Determine if the high salinity brine reservoir is acceptable for geopressured-geothermal energy production.
- Keep well in safe stand-by condition.

2. Geoscience and Engineering Support

a. Rock Mechanics

- Compile previous rock mechanics test data.

b. Liquid Hydrocarbons

- Determine source and flow mechanisms for the liquid hydrocarbons and methane being obtained from producing geopressured reservoirs.
- Construct and field test a pH probe for use in geopressured-geothermal surface facilities.

c. Reservoir Engineering

- Refine the geology at well sites to delineate reservoir size and volume for information necessary to develop accurate reservoir models.
- Analyze well test data and improve reservoir simulators.

d. Logging

- Evaluate logs as required for programmatic activities.
- Complete final report on the effect of trace elements on neutron logs with emphasis on boron in geopressured-geothermal formations.

e. Environmental Effects

- Determine environmental effects of developing geopressured-geothermal reservoirs.

3. Energy Conversion

a. Pleasant Bayou Hybrid Power System

- Complete final report on hybrid power system.

4. Management Support

a. General Administration

- Technical and managerial support to DOE-ID.

b. Technology Exchange

- Provide transfer of new technologies.

## HOT DRY ROCK RESEARCH

1. Fenton Hill Operations

   a. Phase II Energy Extraction System

      - Evaluate the large Phase II reservoir at Fenton Hill to determine its water loss characteristics.

      - Prepare system for Long Term Flow Test.

   b. Phase II Ancillary Activities

      - Comply with applicable regulations for environment, safety and health in connection with operations at Fenton Hill.

      - Acquire adequate water supply to conduct LTFT.

   c. Site Support

      - Maintain the site in the condition necessary to perform planned experimental operations.

2. Scientific and Engineering Support

   a. Reservoir Engineering

      - Develop technology to monitor changes in reservoir volume and temperature to confirm monitoring data using tracers.

      - Complete pre-LTFT reservoir analyses and model expected hydraulic and thermal performance of the Phase II system.

      - Determine means to locate accurately the intersection of fractures with the wellbore.

   b. Technology Applications

      - Determine if the performance of the Fenton Hill Phase II reservoir, when considered as a unit reservoir in a commercial-scale project, could support production of electricity at an economical busbar cost.

## LONG VALLEY EXPERIMENTAL WELL

1. Long Valley Operations

   a. Deepen well to approximately 7,500 feet in cooperation with State of California

      - Monitor well site.

   b. Supporting Science

      - Carry out supporting science experiments in cooperation with other sponsoring groups at the well.

      - Monitor geoscientific activities

2. Laboratory and Engineering Support

   a. Geochemistry and Materials

      - No activities planned.

   b. Energy Extraction

      - No activities planned.

# III. ACTIVITY MILESTONES FY 1991

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | | | | | | | | |
| **HYDROTHERMAL RESEARCH** | | | | | | | | |
| 1. <u>Industrialization</u> | | | | | | | | |
| **State Coupled Grants** | | | | | | | | |
| ● Each grant requires delivery of final draft reports to DOE and UURI 45 prior to the project completion date. | | | | | | | | |
| **Direct Heat Participation** | | | | | | | | |
| ● Continue to provide technical assistance to utilities, businesses, communities, and individuals seeking to develop space or district heating systems, greenhouses, aquaculture applications, and geothermal heat pumps. | | | | | | | | |
| **Heber Binary Demonstration Power Plant** | | | | | | | | |
| ● Continue to facilitate negotiations between the resource owners, plant owners, and prospective buyers of the plant. | | | | | | | | |
| **Geothermal Test Facility** | | | | | | | | |
| ● Remove barrels of possibly hazardous materials. | | ● | | | | | | |
| ● Characterize pond sludge and initiate corrective action. | | | ● | | | | | |
| | | | | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HYDROTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 2. Reservoir Technology | | | | | | | | |
| **Reservoir Analysis** | | | | | | | | |
| ● LLNL to report on The Geysers attenuation image (11/90). | ● → | | → | | | | | |
| ● LBL to document and release additional geothermal modules for MULKOM/TOUGH2 reservoir simulatory (6/91). | → | | ● → | | → | → | | |
| ● LBL to report on study of multi-phase flow in fractured media (1/91). | → | ● → | → | → | → | | | |
| ● ORNL to report on laboratory measurements of hydrogen chloride solubility in geothermal fluids (8/91). | → | → | → | ● → | | | | |
| **Brine Injection** | | | | | | | | |
| ● LLNL to initiate seismic monitoring studies at The Geysers (1/91). | → | ● → | → | → | → | | | |
| ● LBL to perform simulation studies to design new injection experiments and large-scale operations with the purpose of optimizing heat extraction from geothermal reservoirs (1/91). | → | ● → | → | → | → | | | |
| ● Stanford to evaluate tracer test data from industry experiments at The Geysers (2/91). | → | ● → | → | → | → | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HYDROTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 2. Reservoir Technology (Cont'd) | | | | | | | | |
| **Brine Injection (Cont'd)** | | | | | | | | |
| ● UURI to conduct tracer recovery analysis at The Geysers (3/91). | | ● | ● | | | | | |
| ● INEL to initiate evaluation of effects of current and past injection on reservoir performance at The Geysers, and to predict the impact of larger injection operations (10/90). | ● | → | → | → | → | | | |
| **Exploration Technology** | | | | | | | | |
| ● UURI continues development of cross-borehole and borehole to surface electrical geophysical methods and complete field deployment (8/91). | → | → | → | ● | → | → | | |
| **Geothermal Technology Organization** | | | | | | | | |
| ● INEL complete negotiations of additional cost-shared projects through the Geothermal Technology Organization -- (10/90 and continuing). | → | → | → | → | → | → | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HYDROTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 3. Hard Rock Penetration | | | | | | | | |
| **Lost Circulation Control** | | | | | | | | |
| ● Complete testing of encapsulated-accelerator cementitious muds in the high differential-pressure cement tester at Brookhaven (6/91). | | | ● | | | | | |
| ● Complete testing of candidate porous packer fabrics (2/91). | | ● | | | | | | |
| ● Complete feasibility study of downhole injector (2/91). | | ● | | | | | | |
| ● Complete second-phase study of BHTV use in characterizing loss zones (2/91). | | ● | | | | | | |
| ● Identify candidate porous packer setting fluids and initiate testing in the fabric test facility (3/91). | | ● | | | | | | |
| ● Complete laboratory and analytical evaluations of ground rubber tire/walnut shell LCM mixtures (6/91). | | | ● | | | | | |
| ● Complete construction of flow loop and initiate testing of drilling hydraulics transducers (10/90). | ● | | | | | | | |
| ● Initiate design of porous packer service module (4/91). | | | ● | | | | | |
| ● Complete laboratory testing of drillable straddle packer (5/91). | | | ● | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HYDROTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 3. Hard Rock Penetration (Cont'd) | | | | | | | | |
| **Lost Circulation Control (Cont'd)** | | | | | | | | |
| ● Complete flow-loop testing of velocity-level transducer and selected commercial flow transducers (4/91). | | | ● | | | | | |
| ● Complete feasibility study of SEA-MIST concept for emplacing downhole hardware (9/91). | | | | ● | | | | |
| **Rock Penetration Mechanics** | | | | | | | | |
| ● Complete overall systems analysis of geothermal drilling (4/91). | | | ● | | | | | |
| ● Complete analysis of reservoir testing in small diameter wellbores (4/91). | | | ● | | | | | |
| ● Define data requirements for corehold field tests (6/91). | | | ● | | | | | |
| ● Field core hole test site selection and test definition (8/91). | | | | ● | | | | |
| ● Complete survey of PDC bit research applicable to core drilling (9/91). | | | | ● | | | | |
| ● Complete systems analysis of core drilling (9/91). | | | | ● | | | | |
| | | | | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HYDROTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 3. Hard Rock Penetration (Cont'd) | | | | | | | | |
| **Instrumentation** | | | | | | | | |
| ● Evaluate logging services applicable to The Geysers and choose a logging service company. Place a logging contract (1/91). | | ● | | | | | | |
| ● Arrange for access to wells in The Geysers (1/91). | | ● | | | | | | |
| ● Conduct logging exercises (3-9/91). | | ● | — | ● | | | | |
| ● Complete the prototype downhole computer (1/91). | | ● | | | | | | |
| ● Complete the design and construction of a power supply (3/91). | | ● | | | | | | |
| ● Complete the design of the dewar/pressure unit and arrange for its construction (3/91). | | ● | | | | | | |
| ● Complete the dewar and conduct a field test (9/91). | | | | ● | | | | |
| **Geothermal Drilling Organization** | | | | | | | | |
| ● Finalize legal agreement with Unocal on borehole televiewer (11/90). | ● | | | | | | | |
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| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HYDROTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 3. Hard Rock Penetration (Cont'd) | | | | | | | | |
| **Geothermal Drilling Organization (Cont'd)** | | | | | | | | |
| ● Complete televiewer documentation and train Unocal personnel (12/90). | ● | | | | | | | |
| ● Complete joint field testing and transfer all equipment to Unocal (4/91). | | | ● | | | | | |
| ● Field test rotating head seals (6/91). | | | ● | | | | | |
| 4. Conversion Technology | | | | | | | | |
| **Heat Cycle Research** | | | | | | | | |
| ● Complete the 100 day fouling investigation test with the polymer-concrete lined heat exchanger tube at the Salton Sea site (5/91). | | | ● | | | | | |
| ● Report the results of the investigation of the fouling resistance of the polymer-concrete lined heat exchanger tube; include recommendations relative to future testing (7/91). | | | | ● | | | | |
| ● Heat Cycle Research program Review at DOE-HQ (12/91). | | | | | ● | | | |
| | | | | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HYDROTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 4. Conversion Technology (Cont'd) | | | | | | | | |
| **Heat Cycle Research (Cont'd)** | | | | | | | | |
| ● Initiate investigation of condensation behavior of supersaturated expansions with the isobutane working fluid using the two dimensional expansion nozzle (5/91). | | | ● | | | | | |
| ● Complete procurement of reaction turbine to be utilized at the HCRF in the investigation of the condensation behavior of the supersaturated turbine expansions (9/91). | | | | ● | | | | |
| ● Complete the installation of the reaction turbine and begin investigations of impact of supersaturated turbine expansions on turbine performance using the isobutane working fluid (12/91). | | | | | ● | | | |
| ● Complete preliminary evaluation of utilizing a supercritical binary cycle with working fluid mixtures in a standardized, modular binary power plant (9/91). | | | | ● | | | | |
| ● Prepare final report on counter-current flow, in-tube condensation testing of the HCRF (8/91). | | | | ● | | | | |
| **Materials Development** | | | | | | | | |
| ● Complete downhole testing of best candidate lightweight $CO_2$-resistant cement (9/91). | | | | ● | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HYDROTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 4. Conversion Technology (Cont'd) | | | | | | | | |
| Materials Development (Cont'd) | | | | | | | | |
| ● Peer-review publication on FY 1991 work (12/91). | | | | | ● | | | |
| ● Complete field test of HX-1 (5/91). | | | ● | | | | | |
| ● Issue interim report (7/91). | | | | ● | | | | |
| ● Initiate field text of HX-2 (7/91). | | | | ● | | | | |
| ● Complete field test of HX-2 (11/91). | | | | | ● | | | |
| ● Initiate field test of HX-3 (1/92). | | | | | | ● | | |
| ● Complete field test of HX-3 (5/92). | | | | | | | ● | |
| ● Selection of lost circulation control material (9/90). | | | | | | | ● | |
| ● Complete mud displacement test with industry (4/91). | | | ● | | | | | |
| ● Cost-shared field test (9/91). | | | | ● | | | | |
| ● Peer-review publication (12/91). | | | | | ● | | | |
| ● Completion of preliminary testing of lined casing selection (10/90). | ● | | | | | | | |
| ● Complete development of method for joining lined casing selections (3/91). | | ● | | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HYDROTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 4. Conversion Technology (Cont'd) | | | | | | | | |
| **Materials Development (Cont'd)** | | | | | | | | |
| ● Install lined casing string for downhole evaluation (8/91). | | | | ● | | | | |
| ● Identification of metallic surface modification process (12/90). | ● | | | | | | | |
| ● Selection of organic bonding system (3/91). | | ● | | | | | | |
| ● Complete characterization of metal/bonding agent/elastomer interfaces. Initiate long-term autoclave exposures (8/91). | | | | ● | | | | |
| ● Peer-review publication (10/91). | | | | | ● | | | |
| ● Select industrial partner (12/90). | ● | | | | | | | |
| ● Complete stator design and fabrication (6/91). | | | ● | | | | | |
| ● Complete laboratory evaluation (8/91). | | | | ● | | | | |
| ● Issue interim report (9/91). | | | | ● | | | | |
| ● Annual Report (12/91). | | | | | ● | | | |
| **Advanced Brine Chemistry** | | | | | | | | |
| ● Install, calibrate and operate ICP (12/90). | ● | | | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HYDROTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 4. Conversion Technology (Cont'd) | | | | | | | | |
| Advanced Brine Chemistry (Cont'd) | | | | | | | | |
| ● Initiate preparation of a peer-review paper dealing with high temperature/pH bioprocess conditions (2/91). | | ● | | | | | | |
| ● Annual Operating Plan (4/91). | | | ● | | | | | |
| ● Annual Report (12/91). | | | | | ● | | | |
| ● Report on kinetic studies using identified variables (e.g., pH, temperature, etc.). | | | ● | ——— | ——— | ——— | ● | |
| ● Complete analysis and recommendations based on the first generation of modified bioreactors (7/91). | | | | ● | | | | |
| ● Subject to information gained above, consider options for the construction of a model process system (9/91). | | | | ● | | | | |
| ● Publish preliminary user manual for brine chemistry model (11/90). | ● | | | | | | | |
| ● Publish results of $CH_4$-$H_20$-$CO_2$ studies (3/91). | | ● | | | | | | |
| ● Hold workshop on brine model capabilities (12/91). | | | | | ● | | | |
| ● Add initial ORNL data on A1 and $H_2S$ (9/92). | | | | | | | | ● |
| | | | | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HYDROTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 4. Conversion Technology (Cont'd) | | | | | | | | |
| **Advanced Brine Chemistry (Cont'd)** | | | | | | | | |
| ● Refine existing data for se water components, as material becomes available (8/92). | | | | | | | | ● |
| ● Enlarge kinetic data base. | | | | ● | — | — | — | ● |
| ● Establish multi-elemental analysis protocol; refine in FY 1992. | | | | ● | — | — | — | ● |
| ● Integrate mineral recovery scheme into waste cleanup strategy. | | | | | | | ● | |
| ● Initiate materials of chemical engineering studies. | | | | | | | | |
| ● Develop process development/pilot plant designs, using best reactor results. | | | | | | | | ● |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **GEOPRESSURED GEOTHERMAL RESEARCH** | | | | | | | | |
| 1. Well Operations | | | | | | | | |
| **Gladys McCall Reservoir** | | | | | | | | |
| ● Complete long-term pressure buildup monitoring (6/91). | | | ● | | | | | |
| ● Complete short-term flow test and short-term pressure buildup (9/91). | | | | ● | | | | |
| ● P&A or turn over to industry (9/91). | | | | ● | | | | |
| **Pleasant Bayou Reservoir** | | | | | | | | |
| ● Evaluate surface facilities operation and begin pressure buildup test (9/91). | | | | ● | | | | |
| **Hulin Reservoir** | | | | | | | | |
| ● Initiate facility designs (10/91). | | | | | ● | | | |
| ● Initiate development of ES and H and quality assurance (2/91). | | ● | | | | | | |
| 2. Geoscience and Engineering Support | | | | | | | | |
| **Rock Mechanics** | | | | | | | | |
| ● Complete report on rock mechanics testing (9/91). | | | | ● | | | | |
| | | | | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **GEOPRESSURED GEOTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 2. Geoscience and Engineering Support (Cont'd) | | | | | | | | |
| **Liquid Hydrocarbons** | | | | | | | | |
| ● Complete annual report on aromatic hydrocarbon sampling and analysis and pH probe testing (9/91). | | | | ● | | | | |
| ● Complete testing of pH probe in geopressured surface facilities. | | | | ● | | | | |
| **Reservoir Engineering** | | | | | | | | |
| ● Develop methods to analyze single well transient pressure test data (9/91). | | | | ● | | | | |
| ⊜ Establish sensitivity of well and reservoir response to drive mechanisms (9/91). | | | | ⊜ | | | | |
| ● Complete data analysis and model development of the Pleasant Bayou reservoir (9/92). | | | | | | | | ● |
| ● Develop reservoir simulation model representing total test history of Gladys McCall reservoir (9/91). | | | | ● | | | | |
| ● Modify or develop simulation model incorporating geology, geochemistry, rock mechanics and reservoir data, as a result of a conceptual model (9/93). | | | | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **GEOPRESSURED GEOTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 2. Geosciences and Engineering Support (Cont'd) | | | | | | | | |
| Reservoir Engineering (Cont'd) | | | | | | | | |
| ● Complete development of maps of co-located geopressured-geothermal brine with medium-heavy oil. | | | | ● | | | | |
| Logging | | | | | | | | |
| ● Follow test program results at the three design wells and provide logging data as appropriate. | ● | — | — | — | — | — | — | → |
| ● Complete final report on the effect of boron on neutron logs. | | | | ● | | | | |
| Environmental Effects | | | | | | | | |
| ● Microseismic and subsidence monitoring continued at all three well sites. | ● | — | — | — | — | — | — | → |
| ● Water quality monitoring continued at all three well sites. | ● | — | — | — | — | — | — | → |
| ● Continue geological investigations. | ● | — | — | — | — | — | — | → |
| | | | | | | | | |
| | | | | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **GEOPRESSURED GEOTHERMAL RESEARCH (Cont'd)** | | | | | | | | |
| 3. Management Support | | | | | | | | |
| ● Prepare a well-written Annual Operating Plan. | | | ● | | | | ● | |
| ● Prepare INEL Geopressured-Geothermal Monthly Report. | ● | — | — | — | — | — | — | → |
| ● Provide coordination, integration, and technical support to the Reservoir Engineering activities. | | | | ● | | | | ● |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HOT DRY ROCK RESEARCH** | | | | | | | | |
| 1. Fenton Hill Operations | | | | | | | | |
| **Phase II Energy Extraction System** | | | | | | | | |
| ● Complete installation of LTFT system. | | | ● | | | | | |
| ● Continue pressurized tests. | ——— | ——● | | | | | | |
| **Phase II Ancillary Activities** | | | | | | | | |
| ● Log wells during reservoir tests. | | ● | | | | | | |
| ● Acquire water for LTFT. | | | ● | | | | | |
| ● Continue environmental monitoring of water and seismic data. | ——— | ——— | ——— | ——→ | | | | |
| 2. Scientific and Engineering Support | | | | | | | | |
| ● Develop reservoir analyses and modeling of hydraulic and thermal performance. | ——— | ——— | ——— | ——● | | | | ——→ |
| ● Conduct geochemistry analysis of water-mineral interactions and effects on an energy extraction-utilization system and the environment. | | | | | | | | ——→ |
| ● Continue microseismic studies to provide data for long term well operations, reservoir analysis, and environmental monitoring. | ——— | ——— | ——— | ——— | ——— | ——— | ——— | ——→ |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **HOT DRY ROCK RESEARCH (Cont'd)** | | | | | | | | |
| 2. Scientific and Engineering Support (Cont'd) | | | | | | | | |
| ● Continue study of geology and rock data acquired during drilling and coring with rock mechanics (laboratory) tests and theories to compare reservoir analyses, behavior and modeling is necessary for application of the total technology. | | | | | | | | |
| 3. Nutrioso | | | | | | | | |
| ● Provide grant to Arizona Department of Commerce. | | | ● | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **MAGMA RESEARCH** | | | | | | | | |
| 1. Long Valley Operations | | | | | | | | |
| Drilling and Engineering | | | | | | | | |
| ● Analyze Phase II drilling results; prepare final report (9/92). | | | | | | | | ● |
| ● Prepare site for stand down until Phase III (10/91). | | | | | ● | | | |
| ● State of California Study (2/91). | | ● | | | | | | |
| ● Begin Phase II drilling (7/91). | | | | ● | | | | |
| ● Negotiate Contract for follow-on drilling (6/91). | | | ● | | | | | |
| ● Complete Phase II drilling, run casing, and take core (9/91). | | | | ● | | | | |
| ● Complete purchase of 13 1/2" casing (6/91). | | | ● | | | | | |
| Support Sciences | | | | | | | | |
| ● Technical monitoring of geoscientific studies by participating groups (NSF, USGS, DOE/OBES) (10/91). | | | | | ● | | | |
| 2. Laboratory and Engineering Support | | | | | | | | |
| Drilling Techniques | | | | | | | | |
| ● No activities planned. | | | | | | | | |

| ACTIVITIES | Fiscal Year 1991 (Quarters) | | | | Fiscal Year 1992 (Quarters) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **MAGMA RESEARCH (Cont'd)** | | | | | | | | |
| 2. Laboratory and Engineering Support (Cont'd) | | | | | | | | |
| Energy Extraction | | | | | | | | |
| ● No activities planned. | | | | | | | | |
| Geochemistry and Materials | | | | | | | | |
| ● No activities planned. | | | | | | | | |