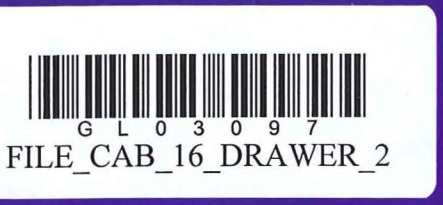

Volume I
Executive Summary

Heber Geothermal Project

Binary-Cycle Demonstration Plant

Proposal By

San Diego Gas & Electric

December 1979

Unsolicited Proposal Submitted To:
Director, Division of Geothermal Energy
U.S. Department of Energy
20 Massachusetts Avenue, N.W.
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Reference No.: PMA 100 Heber Binary

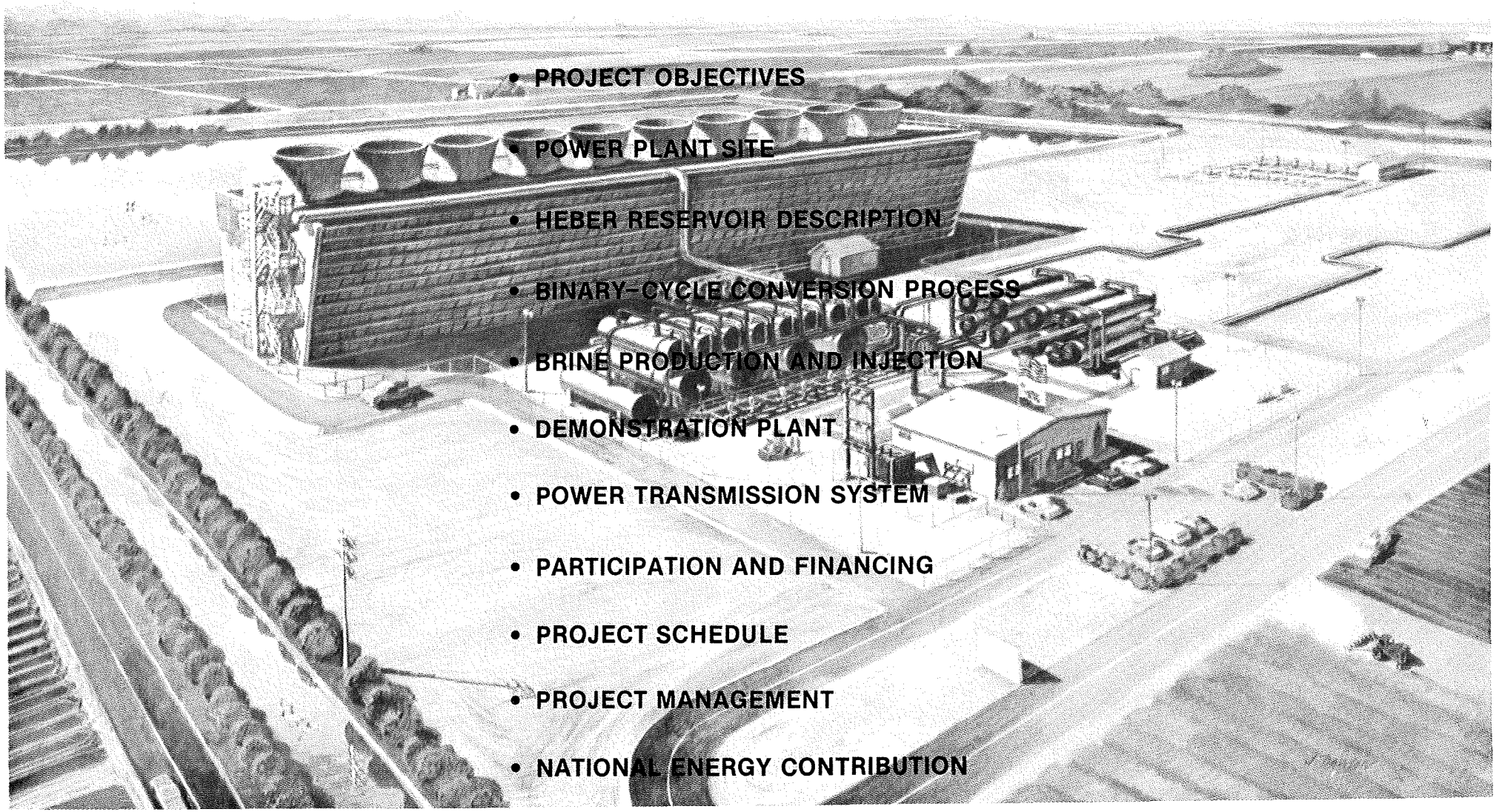
FOREWORD

This volume is part of an unsolicited proposal that we of San Diego Gas & Electric have submitted to the Department of Energy and the Electric Power Research Institute. Our proposal is for these organizations to share with us, and with various electric utilities and California agencies, the cost of a project to design, construct, and operate a commercial size, binary-cycle, geothermal power plant — the first power plant of its kind ever to be undertaken.

This brief volume is intended to acquaint you with the highlights of the project. As you read, you will see that we have tried to anticipate some of your questions: For example, What is a *binary-cycle*, geothermal, power plant and what *promise* does it offer? Where is the plant to be *located*? Who is *involved* in it? and, What are its prospects for *success*? And finally, Why should the federal government assist in the *commercialization* of binary-cycle technology and what are the benefits to the *nation*? The answers to these questions are provided herein.

HEBER BINARY GEOTHERMAL PLANT

TABLE OF CONTENTS



PROJECT OBJECTIVES

The objectives for the Heber Demonstration Project are to:

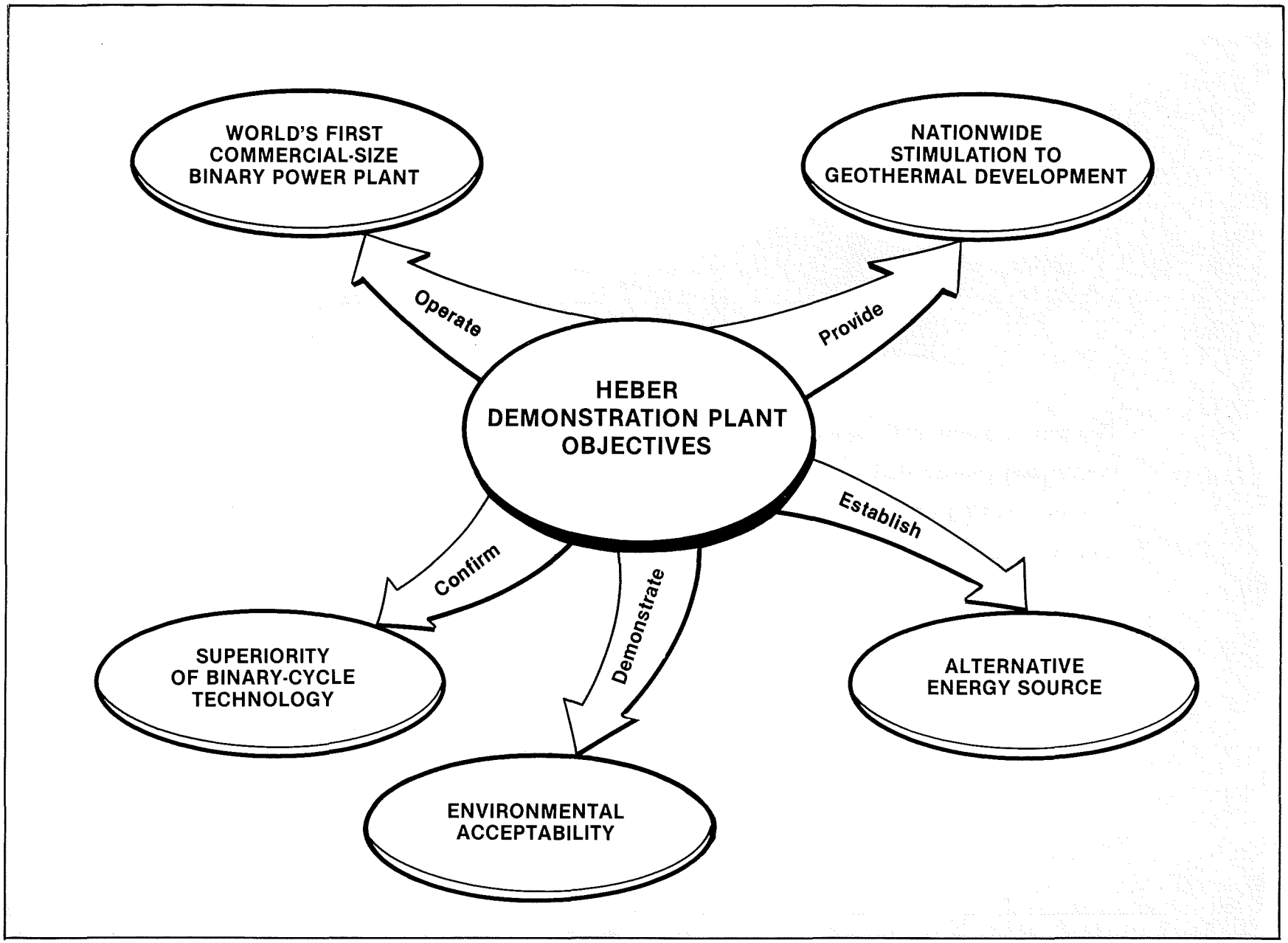
- Design, construct, and operate the world's first commercial-size, binary-cycle, power plant by mid-1984.

- Confirm the binary-cycle as the best overall electric energy conversion technology for moderate temperature (300-400° F) hydrothermal resources.

- Demonstrate the environmental acceptability of large-scale, binary-cycle technology.

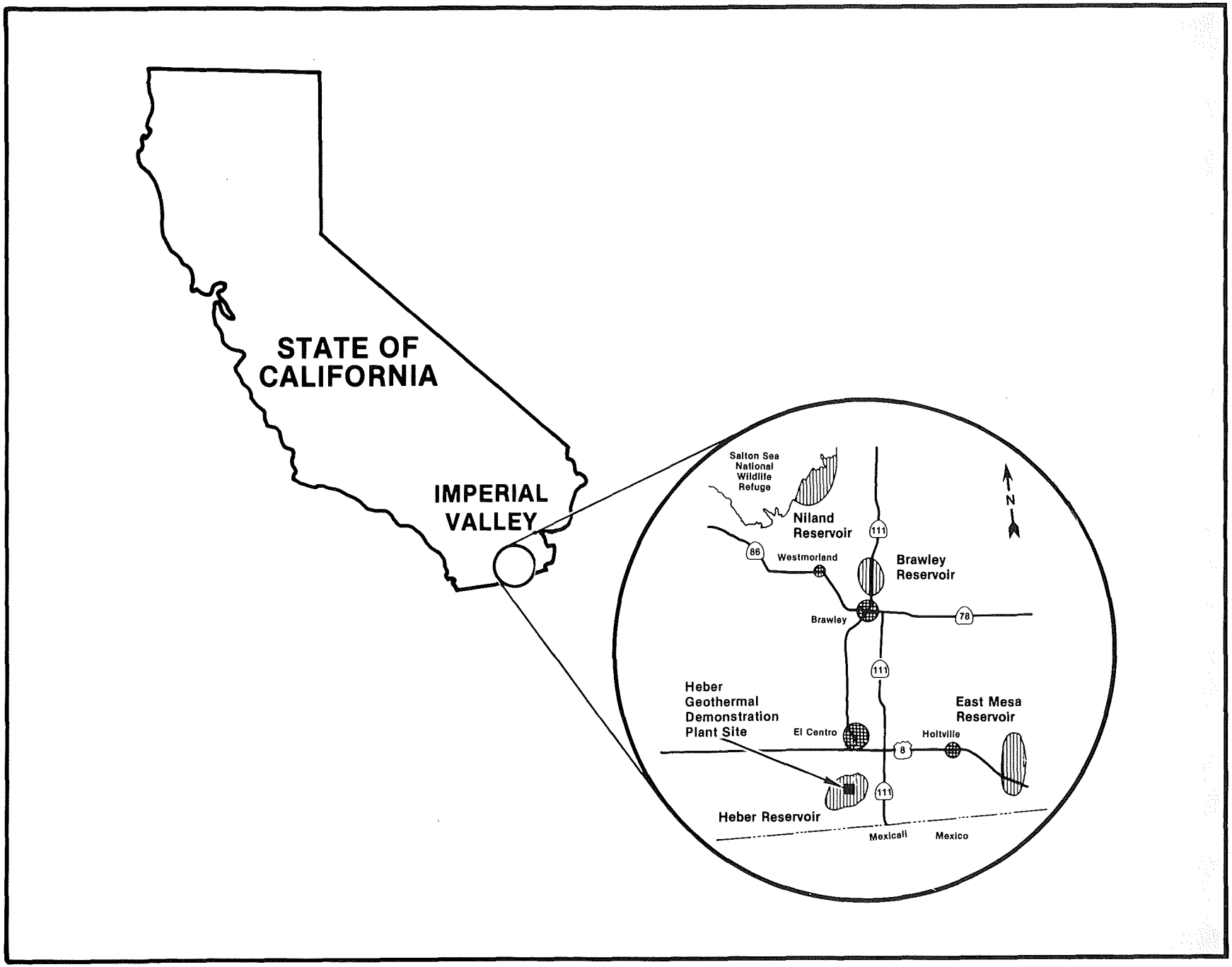
- Provide the Department of Energy with the component and system performance data necessary to stimulate nationwide geothermal development.

- Establish an alternative energy source for electric power generation and to help reduce U.S. dependence on uncertain supplies of foreign oil.


WORLD'S FIRST COMMERCIAL-SIZE BINARY POWER PLANT
NATIONWIDE STIMULATION TO GEOTHERMAL DEVELOPMENT
Operate
Provide
HEBER DEMONSTRATION PLANT OBJECTIVES
Establish
Confirm
Demonstrate
SUPERIORITY OF BINARY-CYCLE TECHNOLOGY
ALTERNATIVE ENERGY SOURCE
ENVIRONMENTAL ACCEPTABILITY

POWER PLANT SITE

The power plant will be located in the Imperial Valley, the heart of the nation's liquid-dominated geothermal activity. The plant site is about one mile south of the town of Heber in southern California and about three miles north of the border between the United States and Mexico. The plant site is owned by San Diego Gas & Electric.

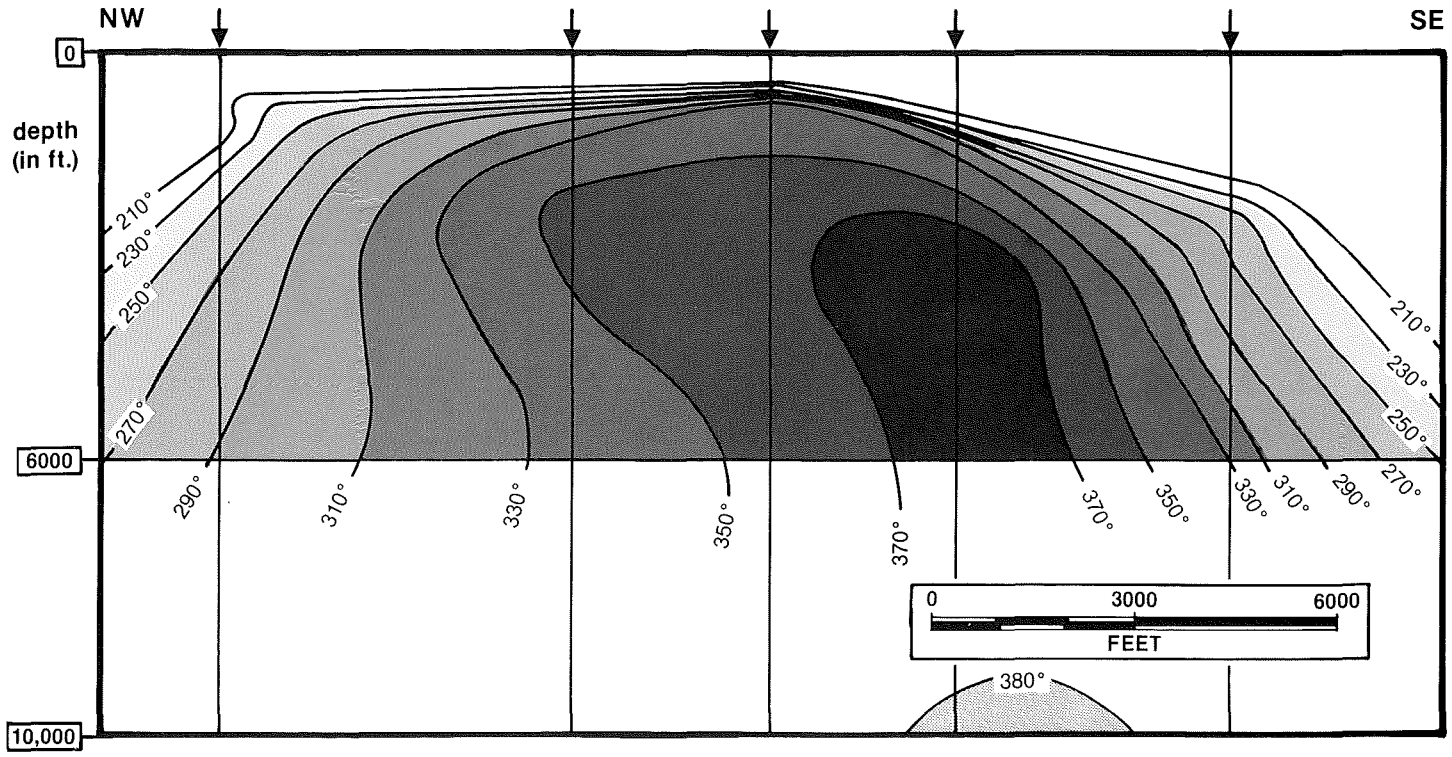

STATE OF CALIFORNIA
IMPERIAL VALLEY
Salton Sea National Wildlife Refuge
Niland Reservoir
Westmorland
Brawley Reservoir
Brawley
Heber Geothermal Demonstration Plant Site
El Centro
East Mesa Reservoir
Holtville
Heber Reservoir
Mexicali
Mexico
N
86
111
78
8

HEBER RESERVOIR DESCRIPTION

The cross-sectional diagram of the Heber Reservoir shows the temperature pattern of the geothermal brine. The darker the shading, the higher the temperature. Fifteen exploratory wells have been drilled at the reservoir with an average depth of 5,500 feet and a maximum depth of 9,700 feet. The reservoir is very well defined to a depth of 6,000 feet.

The Heber Reservoir is "liquid-dominated," meaning simply that most of the brine within it is in a liquid rather than vapor state. The temperature of the liquid is classified as moderate (300-400° F), and the concentration of dissolved solids in the liquid is low. The Heber Reservoir's temperature makes it similar to 80 percent of the known hydrothermal resources in the United States. Thus, the experience gained at Heber would have the widest possible application for future geothermal development in the United States. The experience could also be shared with other countries having similar reservoirs, particularly Mexico.

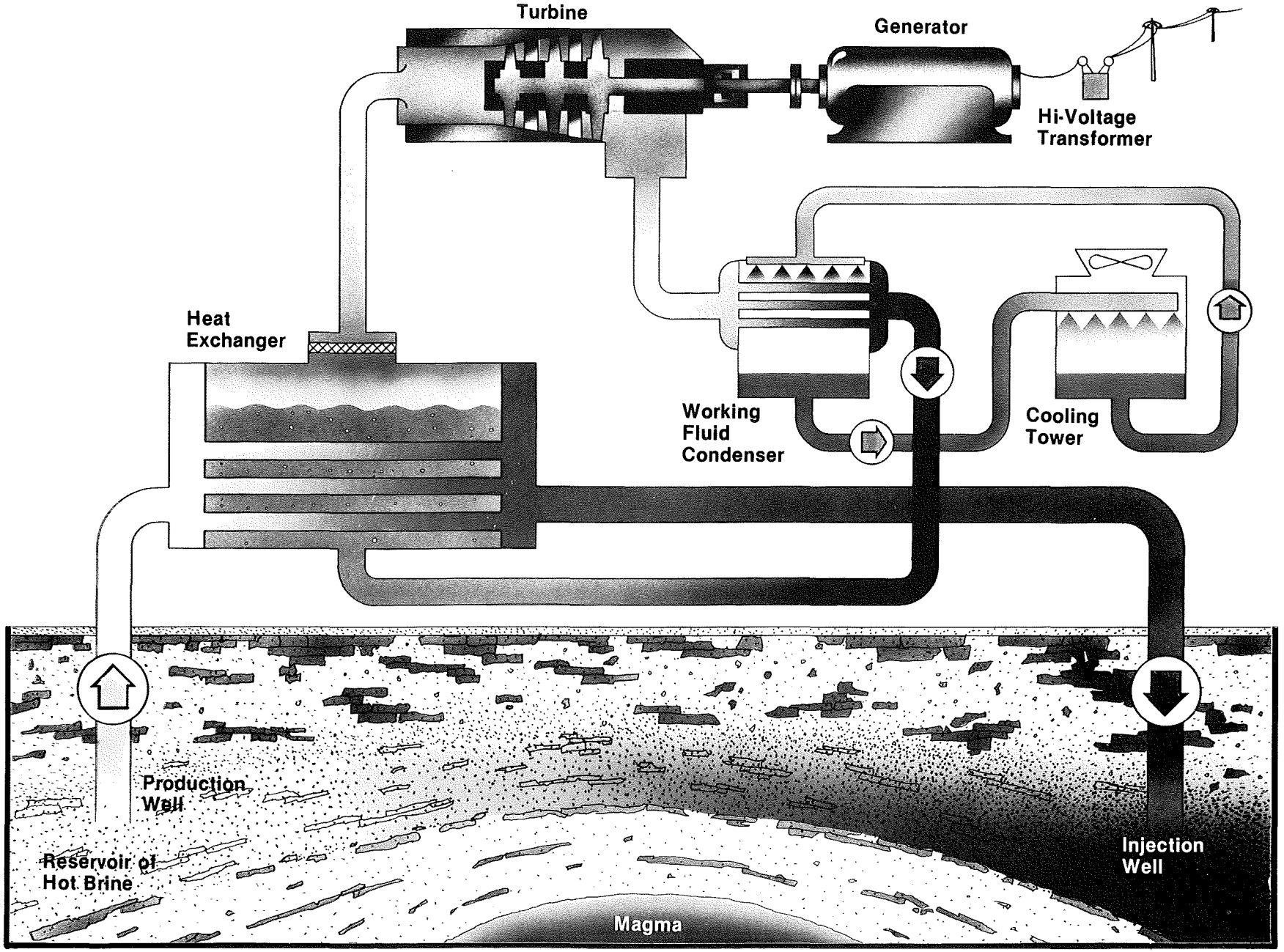
Arrows indicate locations of exploratory wells.



BINARY-CYCLE CONVERSION PROCESS

The Heber Power Plant will use the highly efficient binary-cycle energy conversion process. As shown in the diagram, hot brine is pumped up from the reservoir through production wells, to a heat exchanger, and then back down into the reservoir through injection wells. As the brine passes through the heat exchanger, it yields its heat to a secondary working fluid which then expands to a vapor. This vapor drives a turbine-generator to produce electricity. Cooling water condenses the working fluid before it is returned to the heat-exchanger.

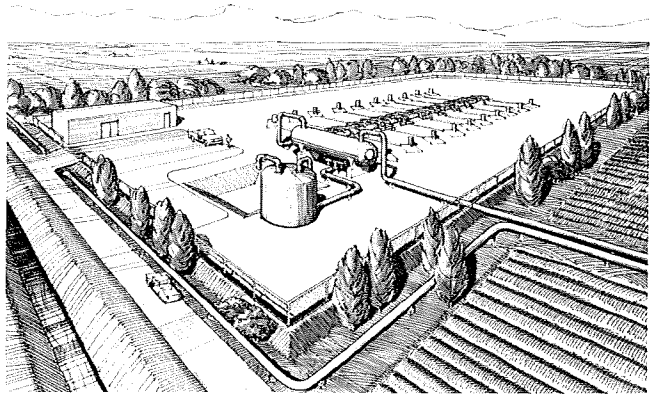
It should be noted that the binary-cycle is a closed system. The brine and working fluids circulate within sealed loops, and none of the fluids or gases are released to the environment. Note also that *all* the brine is returned to the reservoir, thereby reducing the tendency of the land to subside.


Turbine
Generator
Hi-Voltage
Transformer
Heat
Exchanger
Working
Fluid
Condenser
Cooling
Tower
Production
Well
Reservoir of
Hot Brine
Injection
Well
Magma

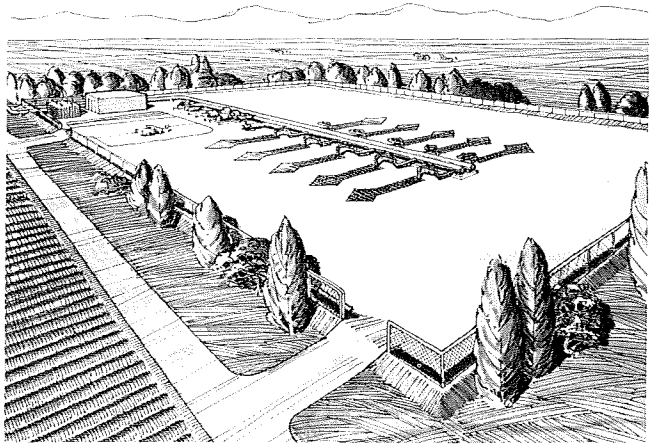
BRINE PRODUCTION AND INJECTION

Geothermal heat will be extracted from the earth through production wells that are directionally drilled into the ground. The well heads are grouped together to form a production island. The island concept reduces land use and minimizes environmental impact. Brine will be extracted at temperatures near 360° F and pumped from the production wells to the power plant.

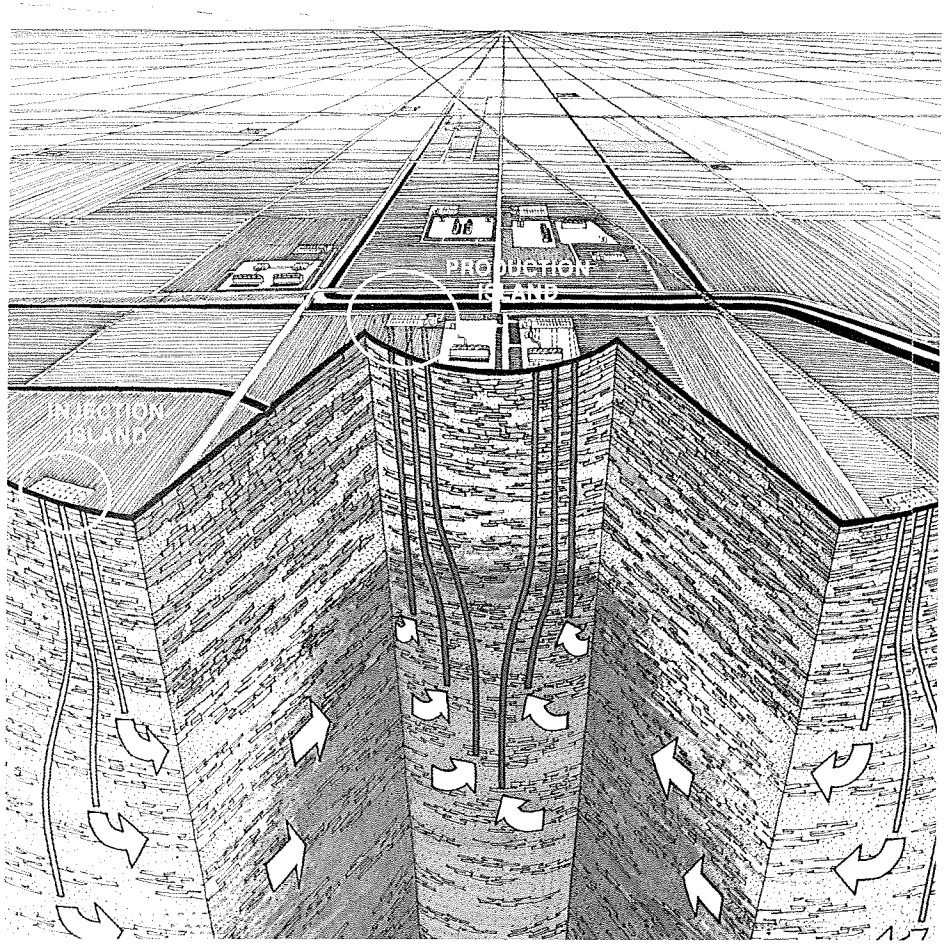
After the hot brine has released its heat to generate electricity, the cooled brine will be returned to injection wells. These wells will also be grouped together to form an injection island. The island concept is a desirable and acceptable method of reducing land use. Injection at the periphery of the reservoir is a means of recyling the geothermal fluid to extract more heat from the reservoir.



Production Island



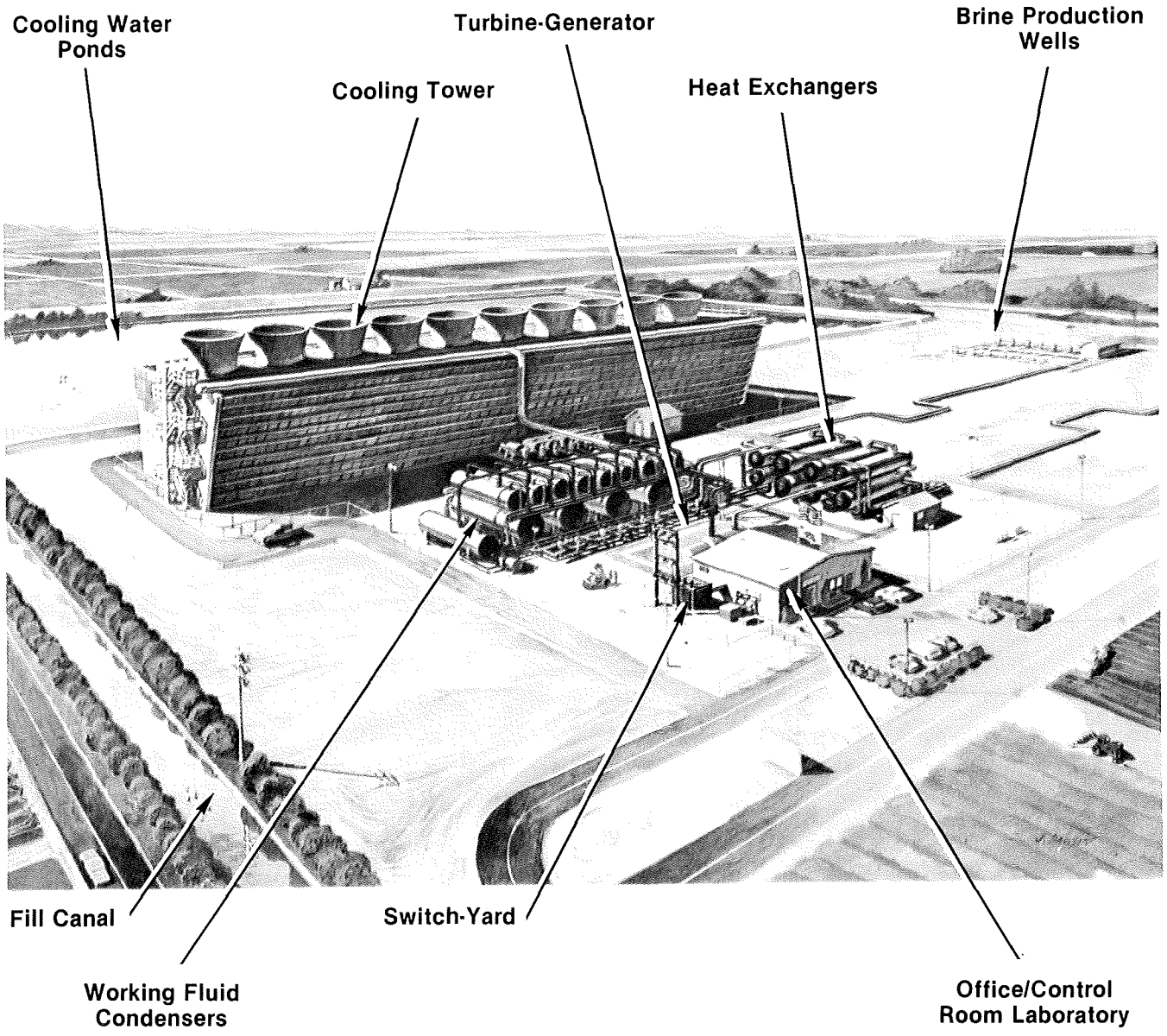
Injection Island



Cutaway view of earth depicting several power plants at same reservoir.

DEMONSTRATION PLANT

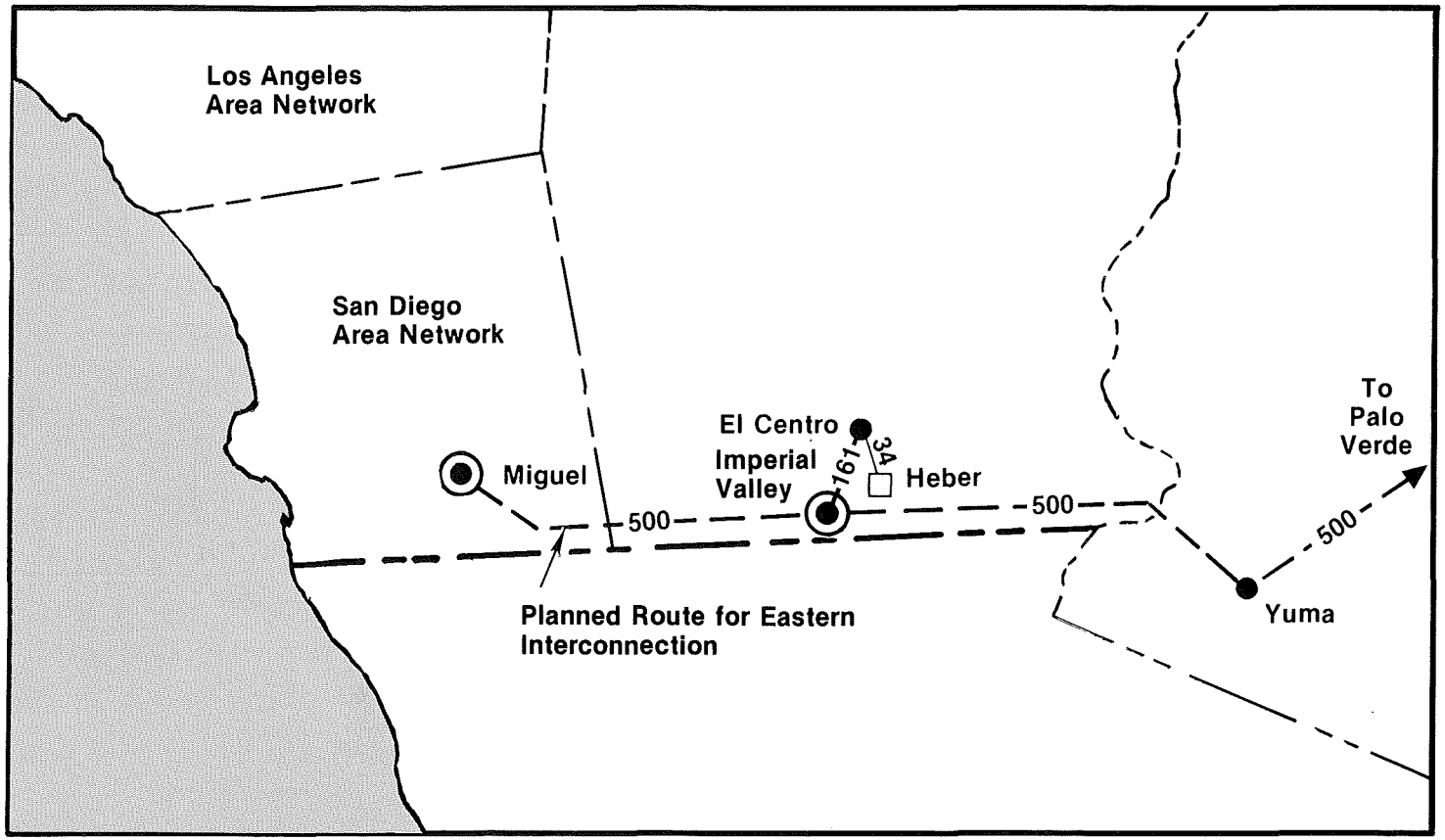
The demonstration plant and its adjacent production island are a compact arrangement that require no more than 20 acres of land. The compact arrangement is a result of an outdoor design. The turbine-generator, heat exchangers, and condensers are not enclosed. This arrangement features a reduction in capital cost and easy access for servicing. The injection island is located about 1 mile from the plant, at the periphery of the reservoir. Cooling water will be supplied to the plant by the Imperial Irrigation District through their system of irrigation canals.


Cooling Water Ponds
Turbine-Generator
Brine Production Wells
Cooling Tower
Heat Exchangers
Fill Canal
Switch-Yard
Working Fluid Condensers
Office/Control Room Laboratory

POWER TRANSMISSION SYSTEM

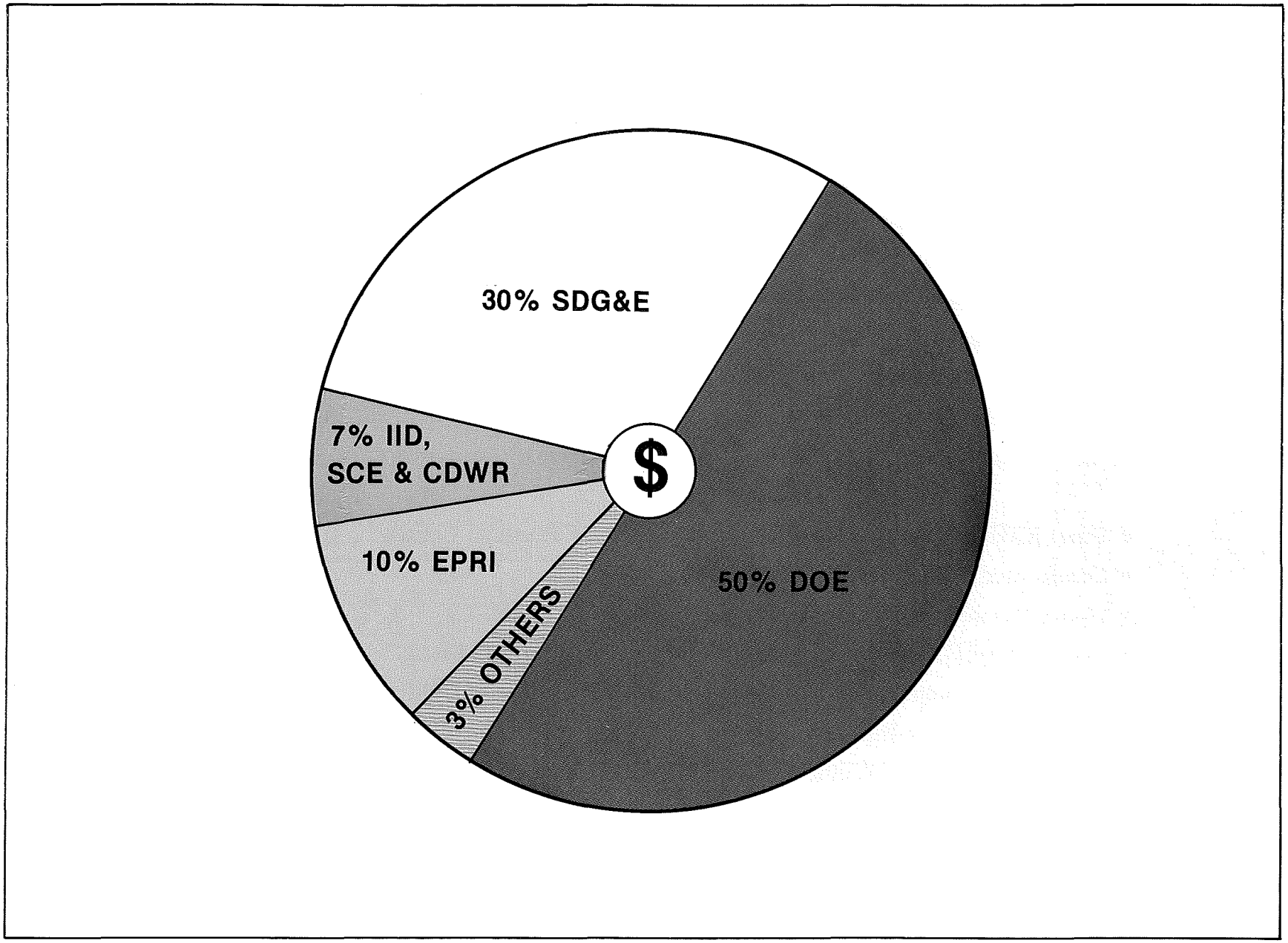
Power from the Heber Demonstration Plant will be transmitted to El Centro by the Imperial Irrigation District's 34-kV lines and then over a planned 161-kV line to the Imperial Valley Substation. From this substation the power will be transmitted over SDG&E's planned 500-kV Eastern Interconnection to the metropolitan areas of Southern California. The Eastern Interconnection is budgeted and scheduled for completion in 1984.

Some of the electrical power will be used in the Imperial Valley and the remainder will be transmitted to San Diego and Southern California.


Los Angeles
Area Network
San Diego
Area Network
Miguel
El Centro
Imperial
Valley
161
34
Heber
500
500
500
To
Palo
Verde
Yuma
Planned Route for Eastern
Interconnection

PARTICIPATION AND FINANCING

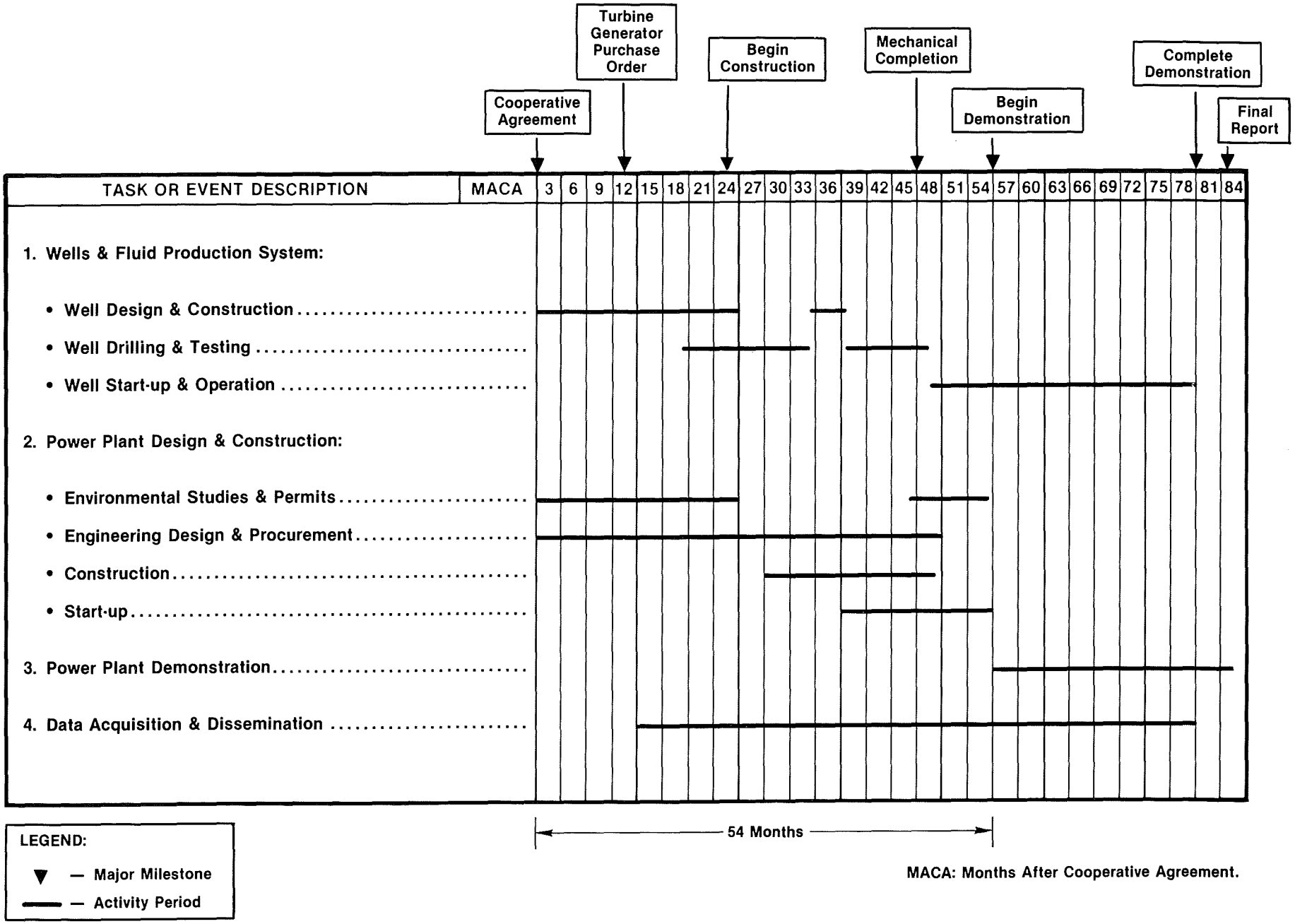
The parties that have expressed their interest in being co-owners with SDG&E are the Imperial Irrigation District, the Southern California Edison Company and the California Department of Water Resources. The Electric Power Research Institute and the Department of Energy are expected to provide financial assistance to the project without ownership interest. Other utilities and California state agencies are also expected to provide contributions to the project. Based upon letters of interest from the prospective co-owners and EPRI, we have developed the cost sharing plan shown in the diagram.


30% SDG&E
7% IID,
SCE & CDWR
$
10% EPRI
3% OTHERS
50% DOE

PROJECT SCHEDULE

The project term is 82 months. It will begin with the Cooperative Agreement between the DOE and SDG&E and will end four months after a two-year power plant demonstration. At the conclusion of the project, SDG&E will submit a final project report to the DOE and the Electric Power Research Institute. Because of the progress already accomplished in design and licensing, engineering will begin immediately. Construction starts in the twenty-fifth month and demonstration starts in the fifty-fourth month. The following significant achievements form the basis of our confidence that all milestones of the schedule can be met:

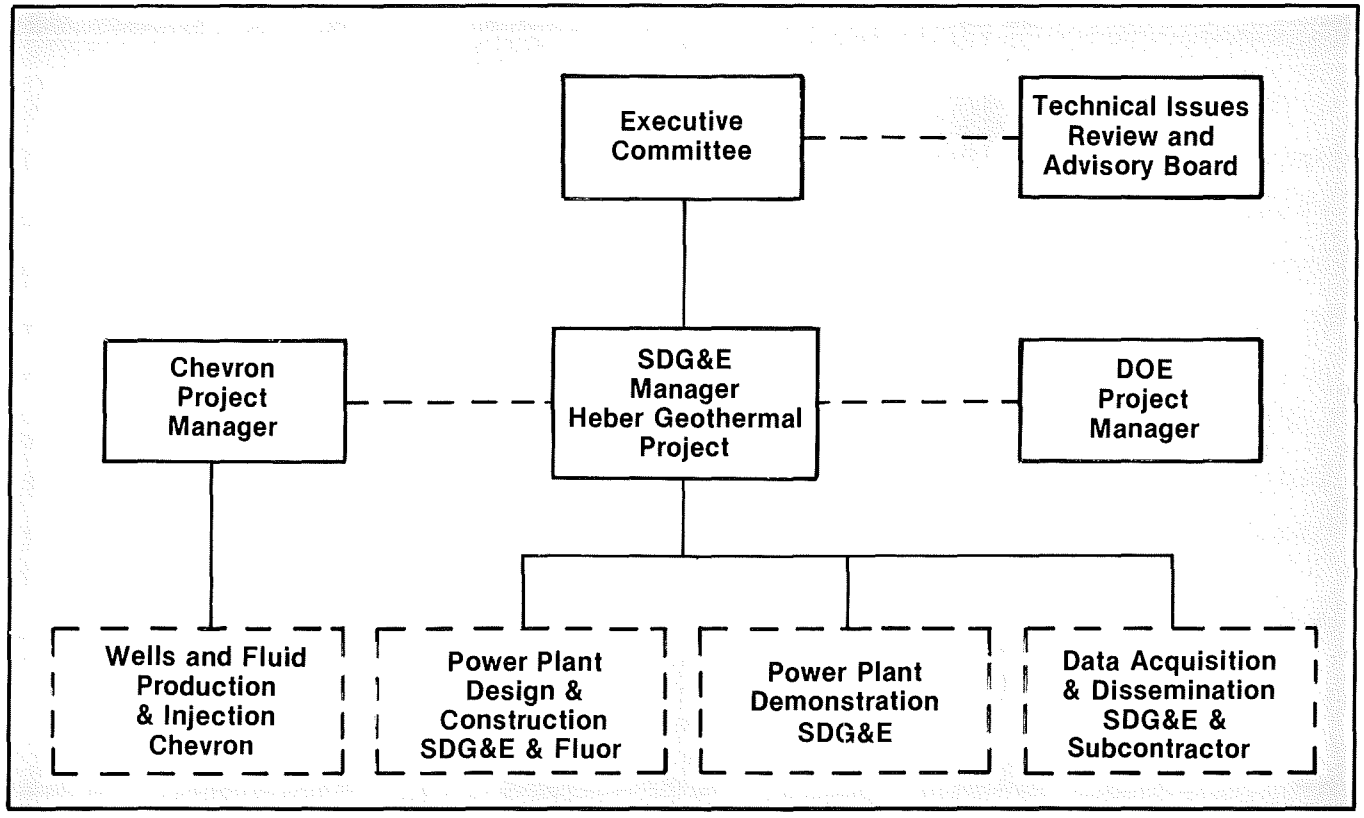
- Final Environmental Impact Report certified by Imperial County.
- Conditional Use Permit issued by Imperial County.
- Heber Demonstration Plant Site purchased by SDG&E.
- Water Supply Agreement signed by Imperial Irrigation District.
- Long Term Cooling Water Negotiations with the State of California nearly completed.
- Favorable Project Resolution adopted by California Energy Commission.
- Favorable Project Resolution adopted by California Public Utilities Commission.


Cooperative Agreement
Turbine Generator Purchase Order
Begin Construction
Mechanical Completion
Begin Demonstration
Complete Demonstration
Final Report
TASK OR EVENT DESCRIPTION
MACA
3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54 57 60 63 66 69 72 75 78 81 84
1. Wells & Fluid Production System:
• Well Design & Construction
• Well Drilling & Testing
• Well Start-up & Operation
2. Power Plant Design & Construction:
• Environmental Studies & Permits
• Engineering Design & Procurement
• Construction
• Start-up
3. Power Plant Demonstration
4. Data Acquisition & Dissemination
54 Months
LEGEND:
▼ — Major Milestone
— Activity Period
MACA: Months After Cooperative Agreement.

PROJECT MANAGEMENT

Executive control of the project rests with an Executive Committee, which is composed of members of the participating organizations. Supporting the project is a Technical Issues Review and Advisory Board, which will provide a strong technical foundation for the decisions of the Executive Committee. The Manager of the Heber Geothermal Project will report directly to the Executive Committee, and he will be responsible for the daily activities of the project. He has total responsibility and commensurate authority for all technical, cost, and schedule aspects of the project within the scope of project agreements.

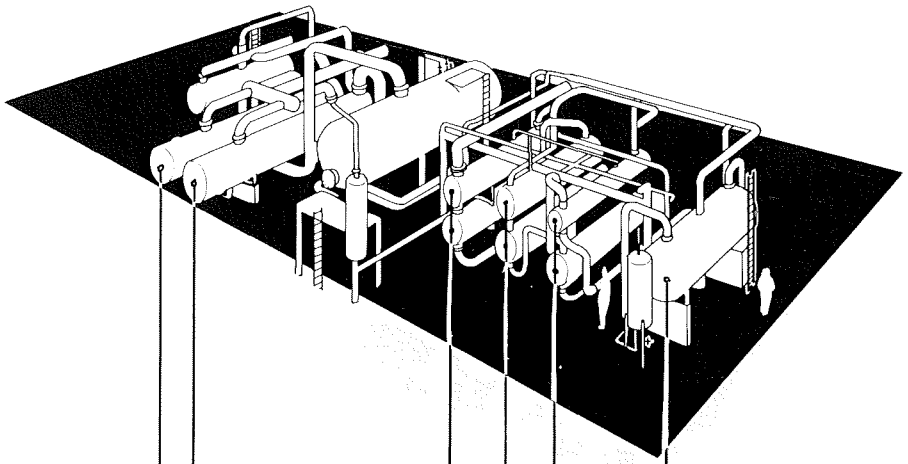
Having been a leader in geothermal development in the Imperial Valley for the past eight years, SDG&E is well qualified to manage the project. Our experience, which includes a successful working relationship with the DOE at the Niland Geothermal Loop Experimental Facility, is a firm foundation for the Heber Binary Project. Chevron is the major leaseholder on the Heber Reservoir and has been designated the Unit Operator for evaluation and development of the reservoir. Chevron has a large base of expertise to draw upon for well drilling and resource extraction and injection. Fluor's qualifications as engineers and constructors include major experience in the fields of refining, chemical processing, and power generation. They also provided the conceptual design for this plant and conducted design optimization studies. This experience will be directly applied to the project.

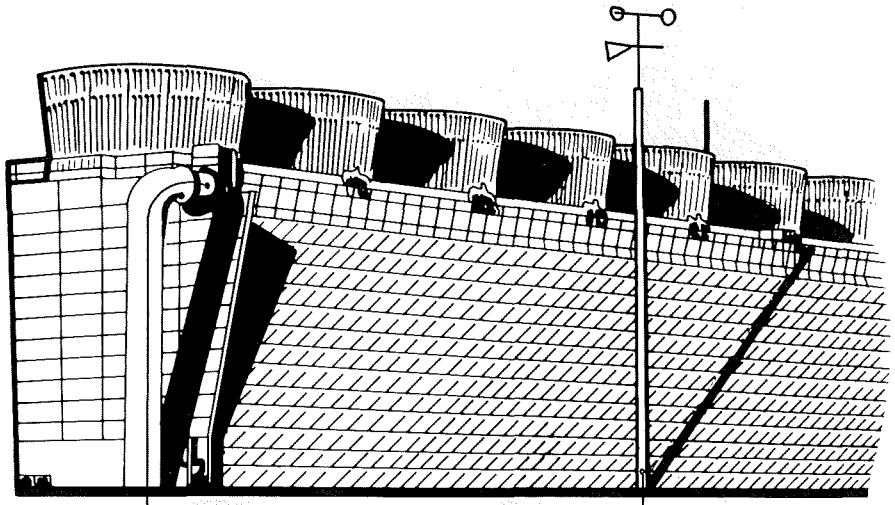

Executive Committee
Technical Issues Review and Advisory Board
Chevron Project Manager
SDG&E Manager Heber Geothermal Project
DOE Project Manager
Wells and Fluid Production & Injection Chevron
Power Plant Design & Construction SDG&E & Fluor
Power Plant Demonstration SDG&E
Data Acquisition & Dissemination SDG&E & Subcontractor

NATIONAL ENERGY CONTRIBUTION

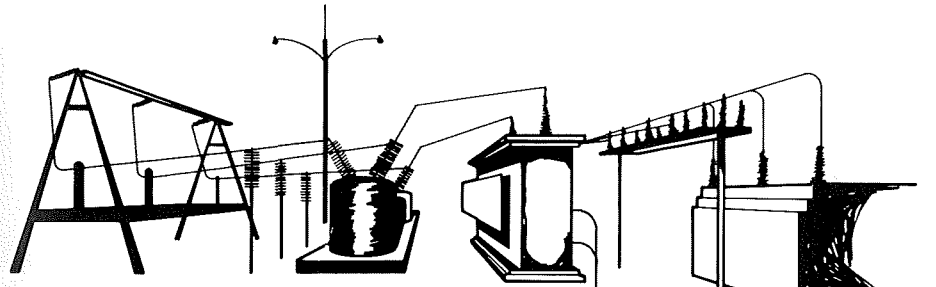
A vital benefit of this project is the information it will yield for the geothermal industry and the public. This is the principal reason for the Department of Energy and the Electric Power Research Institute to share in its cost. Applied on a commercial scale, the binary technology presents a means of developing the majority of the nation's geothermal resources. However, it also presents a financial uncertainty. Before the finanancial community, resource developers, equipment manufacturers, and electric utilities will make the necessary commitment to it, they require information on all facets of the technology. Only with such information can they determine that the technology is qualified for a commercial venture.

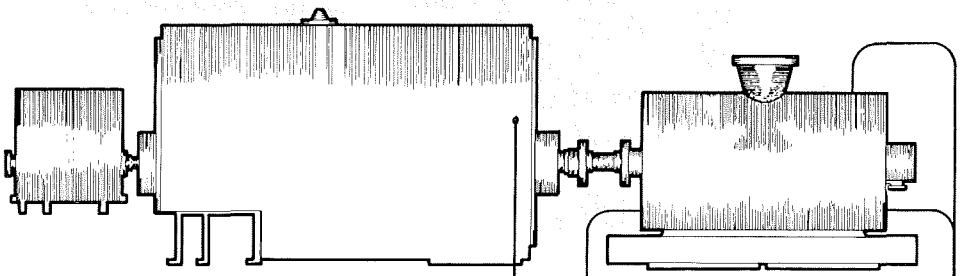
The following pages present an overview of how this information will be collected and disseminated, and of how it can be put to use to relieve the nation's energy situation.

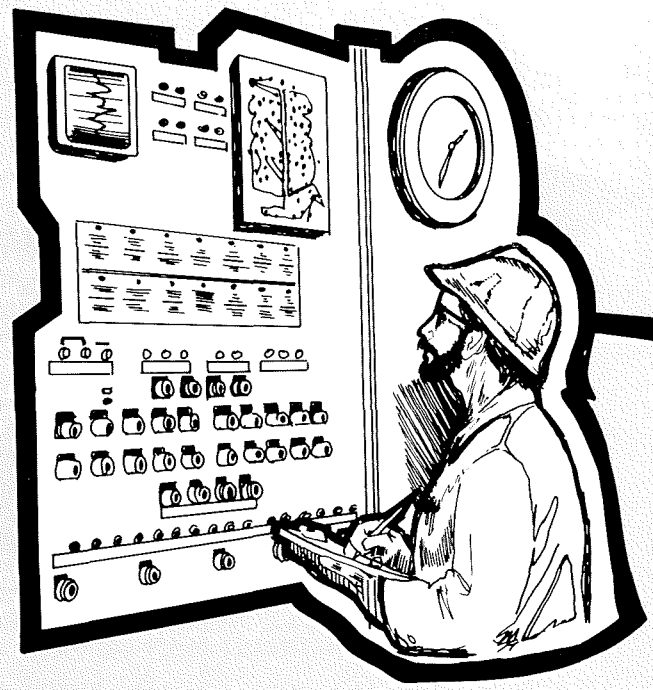




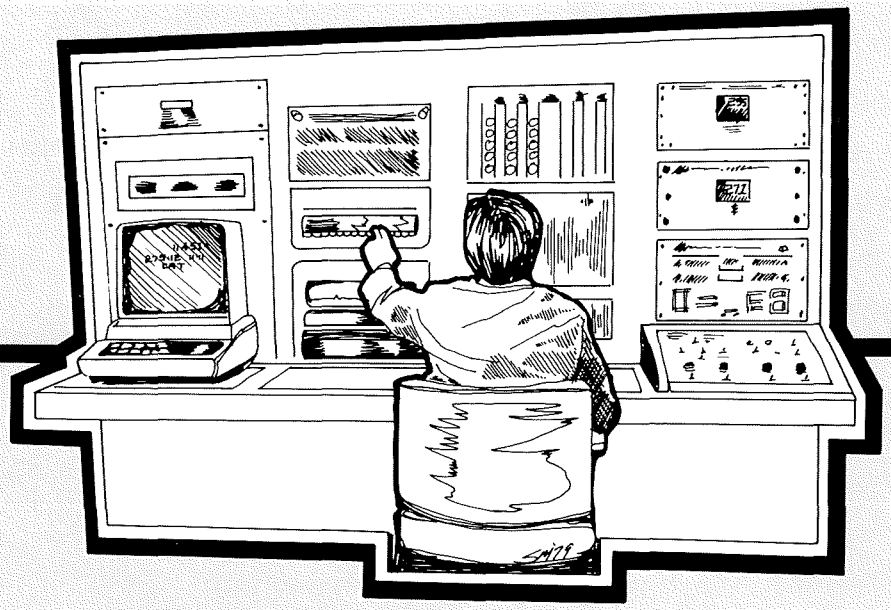
Plant systems will be wired with sensors . . .





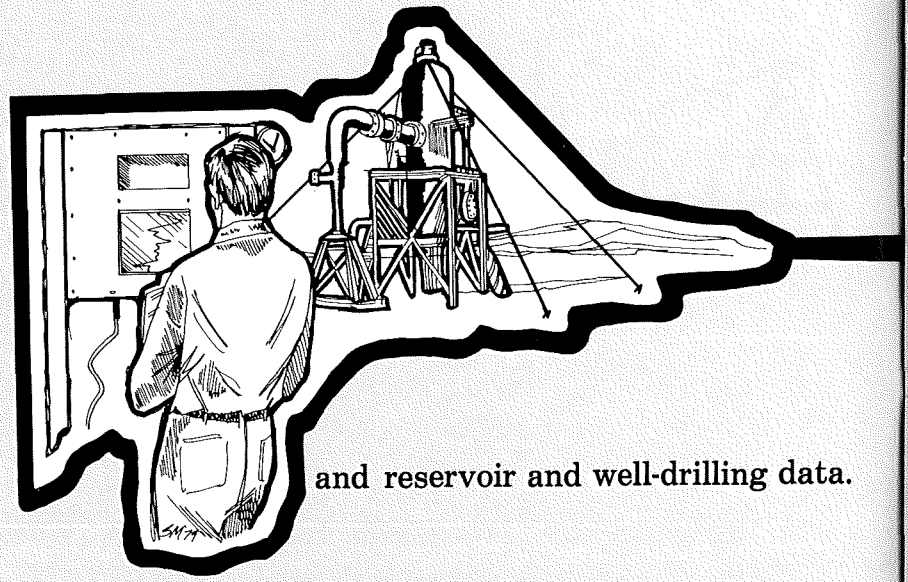


normal
plant records . . .



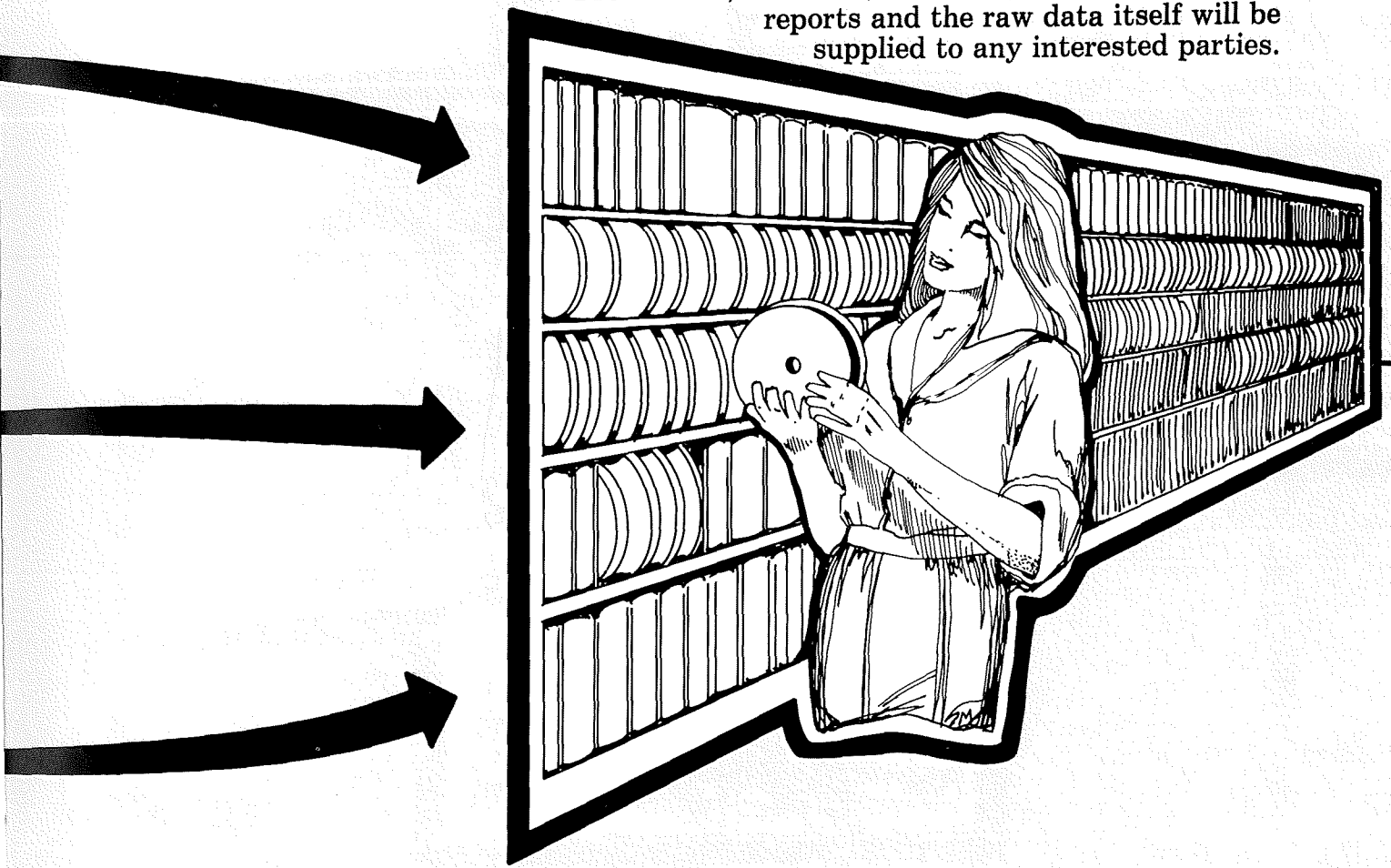
. . . and monitored at a central control room. There, the data will be processed and stored on tape and on hard copy print-out.

Other sources of information will be . . .

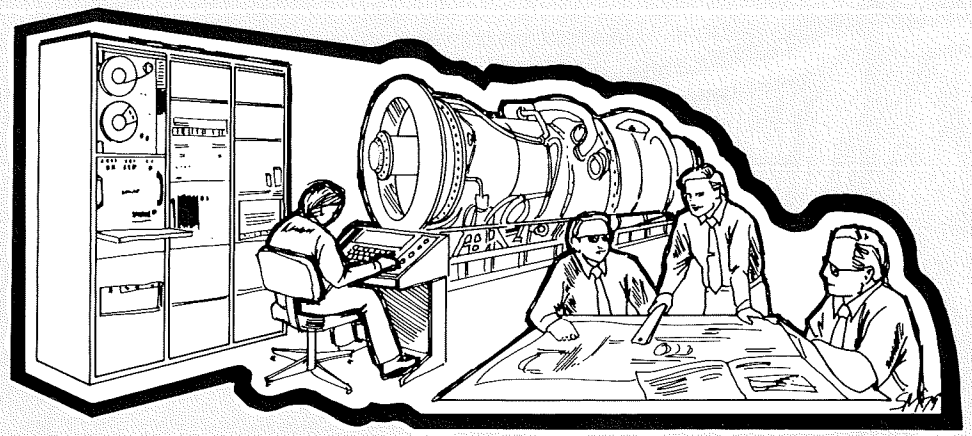


and reservoir and well-drilling data.

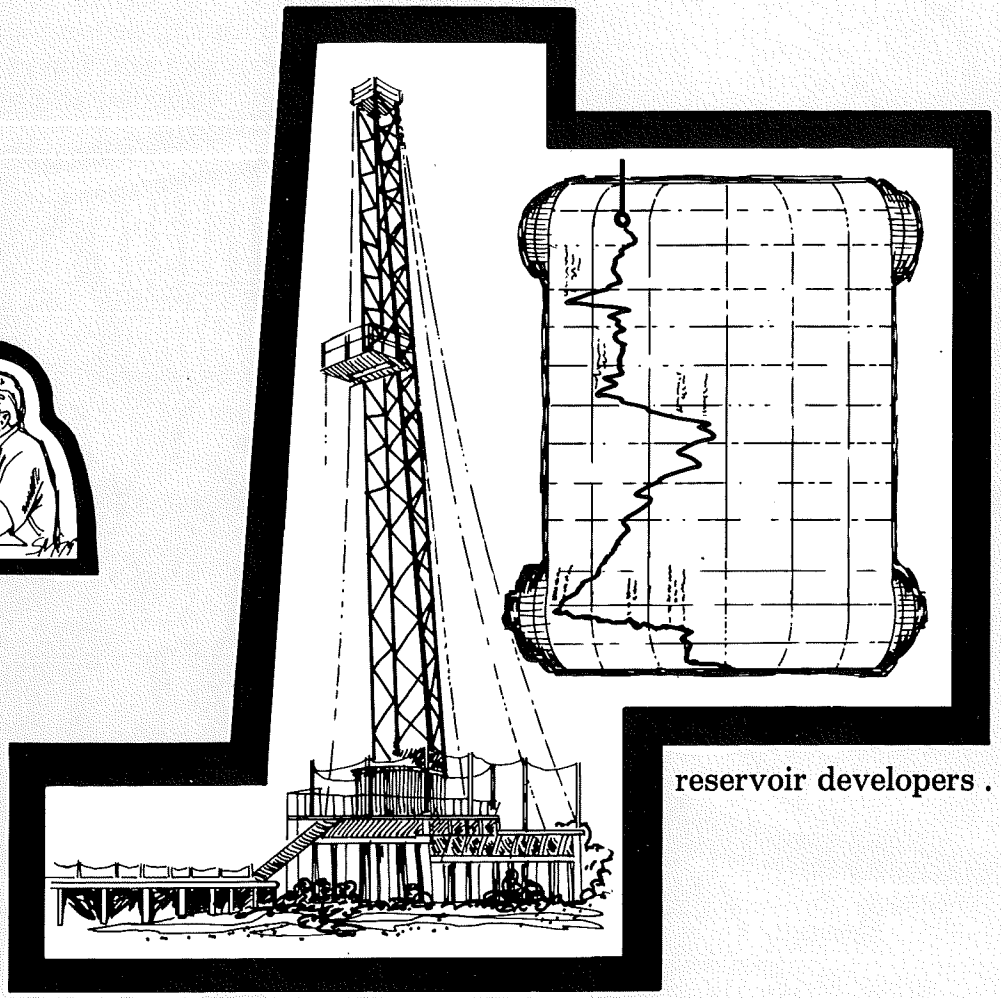
The information will be collected at a central location. From there, technical, economic, and environmental reports and the raw data itself will be supplied to any interested parties.



Some of the users of this information will be . . .



equipment manufacturers . . .



reservoir developers . . .

public forums . . .

. . . and local, state, and federal agencies

But the most comprehensive use of this information will be made by . . .

the geothermal industry itself — to make decisions regarding the binary process and to plan future plants.

A cooperative industrial training program will begin with the Heber Project. The objective of this program is to supply these future plants with a cadre of trained operators.

And this is the ultimate objective of the project and the benefit to the nation:

- To reduce our dependence on foreign sources of energy.
- To develop an alternate energy source that is economically and environmentally acceptable.