HEBER BINARY PROJECT

Briefing Document

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I. PROJECT BACKGROUND

Summary

The Heber Binary Project is based on studies performed for the Electric Power Research Institute (EPRI), which identified the need for a commercial scale (50 Mw or larger) demonstration of the binary cycle technology. Because of its extensive background in geothermal work, San Diego Gas & Electric (SDG&E) agreed to undertake the management of the Heber Binary Project. A consortium consisting of SDG&E, DOE, EPRI, the California Department of Water Resources (DWR), the Imperial Irrigation District (IID), and the Southern California Edison Company (SCE) has been formed to pursue the Project.

The Heber Binary Project had its beginning in a study performed for the Electric Power Research Institute (EPRI) by Holt/Procon. The purpose of the study was to evaluate alternate technologies that could be used to exploit the extensive low- to moderate-temperature geothermal reservoirs in the United States. The study also screened 17 candidate reservoirs to determine which would be best to demonstrate the selected technology on a commercial (50 Mw or larger) scale. The study concluded that the binary cycle showed the most promise for application to low- to moderate-temperature reservoirs, and that the Heber reservoir was one of the best sites to demonstrate the technology on a commercial scale. Figure 1 shows the Project site.

In 1977, SDG&E agreed to manage a demonstration project with a capacity of 65 Mw (gross) that would be located on the Heber reservoir. This decision was based on SDG&E's extensive geothermal experience and EPRI's supporting work. Consequently, a project was formed with participation by SDG&E, EPRI, six other utilities, two reservoir developers, and the California Energy Commission. Engineering and environmental studies were initiated and efforts

Figure 1 Heber Binary Project Site

were made to obtain federal funding for the portion of project costs that could not be financed by industry. In 1978, federal funding was not forthcoming and because the risk of this first-of-a-kind project was greater than industry could assume, the project was terminated.

In 1979, SDG&E again submitted a project proposal. This proposal was accepted by DOE, and in September 1980 the parties signed a Cooperative Agreement. Other agreements to carry out the newly-formed project have been signed with EPRI and a group of three utilities--the Imperial Irrigation District, California Department of Water Resources, and Southern California Edison Company.

SDG&E Background In Binary Cycle Development

SDG&E has conducted geothermal exploration, research, and field test development since early 1971. We have identified three promising reservoirs in the Imperial Valley of California. These are located at the south end of the Salton Sea near Niland, south of El Centro near Heber, and east of Holtville at East Mesa. Two of these, Heber and East Mesa, are prime candidates for development using the binary cycle.

SDG&E began conducting field loop tests applicable to binary cycle technology at Niland in 1973. Small heat exchangers, with the hot, highly mineralized brine flowing directly through the tubes, were used to heat a working fluid. These tests revealed the high scaling tendencies of the Niland brines, and the Company set about to develop ways to overcome this problem. In 1974, a multi-stage flash/binary system was designed. It removed heat from the geothermal fluid in the form of steam. Based upon field tests of this system and under a 50-50 cost sharing arrangement with DOE, SDG&E built and operated a 10 Mw Geothermal Loop Experimental Facility (GLEF) to evaluate the potential of the reservoir and the practicality of the flash/binary conversion process.

To determine scaling characteristics of the Heber brine, SDG&E, in cooperation with EPRI and Chevron Resources Company, conducted heat exchanger tests at this reservoir in 1974. These tests consisted of a series of 500-hour runs with four small heat exchangers and three different tube materials. EPRI followed the first 500-hour heat exchanger test with a 2,000-hour test, which verified the findings of the first scaling and corrosion tests. Data from the testing program formed the basis for full-scale design criteria for the Heber Binary Project.

II. IMPORTANCE OF THE BINARY CYCLE

Summary

Availability of the binary cycle technology on a commercial scale will permit the development of moderate-temperature (below 410°F) geothermal reservoirs. Approximately 50 percent of the potential electric production from hydrothermal reservoirs in the United States will come from moderate-temperature reservoirs. The binary cycle is also required to exploit hot dry rock and geopressured resources.

The utility industry has only one commercially available cycle that may be used to develop liquid-dominated hydrothermal reservoirs--the flash cycle. With the flash cycle, the hot geothermal fluid flows under pressure to a vessel where the fluid is allowed to boil, or flash, to produce steam. The steam then runs the turbine in a conventional manner. The flash cycle is proven and has been in commercial service for a number of years, but its use is limited to high temperature (over 410°F) reservoirs.

The flash cycle is effectively ruled out at moderate-temperature (below 410°F) reservoirs. It is not practical to flash the geothermal fluid at pressures lower than atmospheric; thus, the geothermal fluid will leave the plant at about 212°F, taking with it much of the heat that would be converted to electricity if flashing could occur at subatmospheric pressures. A second limiting factor is that more than two stages of flash are not cost effective, and in practice, the geothermal fluid may leave the plant at a temperature higher than 212°F. A third limitation is that if the geothermal fluid is flashed at low pressures, the turbines using this low pressure steam must be large and are, therefore, expensive. Finally, noncondensable gas in the flashed steam could impose severe economic penalties by requiring large amounts of power for its removal. The release of noncondensable gases, often containing

hydrogen sulfide, to the atmosphere also results in an adverse environmental impact.

The binary cycle will overcome the limitations of the flash cycle when applied to moderate-temperature reservoirs. This concept uses heat exchangers to transfer heat from the hot geothermal fluid to another liquid known as the working fluid. The working fluid is heated and vaporized and then used to drive the turbine to produce electricity. A working fluid can be selected which has a boiling point equal to the prevailing temperature of the geothermal resource. The amount of energy production is limited only by the ambient wet bulb air temperature. This flexibility allows us to generate electricity from the moderate-temperature reservoirs and improve resource utilization at other reservoirs. The binary cycle also provides other potential advantages, such as greater efficiency of energy extraction, elimination of noncondensable gas emissions, and elimination of steam carryover problems.

A simplified process flow diagram for a binary cycle power plant is shown in Figure 2.

Figure 2 Simplified Process Flow Diagram of the Binary Conversion System

To gauge the importance of the binary cycle, about four out of five hydrothermal reservoirs in the United States are moderate-temperature reservoirs and will require the binary cycle for both technical and economic reasons. Furthermore, if, as expected, reservoir temperatures decline with time, the need for the binary cycle will become even greater.

Another way of gauging the need for the binary cycle is to examine the total electric production that can be developed from hydrothermal reservoirs. In June 1980, the Interagency Geothermal Coordinating Council, chaired by DOE, established the goal of 25,000 Mw of electric capacity from hydrothermal reservoirs by the year 2000. This equals about 340 million barrels of oil each year. The binary cycle will account for at least half of the 25,000 Mw goal. In fact, the binary cycle could account for all of the 25,000 Mw because it is applicable to all reservoirs over the entire spectrum of reservoir temperatures.

Importance of the Binary Cycle Technology to Other DOE-Sponsored Programs

To extract energy from a hot dry rock resource, a manmade hydrothermal reservoir is formed by connecting two deep holes in impermeable rock through a system of fractures in the rock, which are produced by pressurizing water. Cold water flows down the deeper hole, is heated by the hot rock in the underground fracture system, and is brought to the surface in the second hole as superheated water under sufficient pressure to keep it from boiling or flashing. After the hot water runs through a heat exchanger at the surface, it is pumped back down the injection hole. Because the hot water is kept under pressure, the only way to use its heat is to transfer it to a working fluid in a heat exchanger. This constraint dictates the use of the binary cycle if the heat is to be used to generate electric power.

All of the geopressured aquifers which have been evaluated contain low- to moderate-temperature water (below 410°F). The binary cycle has to be used to convert the thermal energy from geopressured reservoirs for the purpose of generating electric power.

III. ORGANIZATION OF THE PROJECT

Summary

A functional organization has been created to implement the Heber Binary Project goals. This project-oriented organization features strong, central lines of communication and authority between the Sponsors' Management Committee and the SDG&E Project Manager, and between the SDG&E Project Manager and individuals and contractors assigned to carry out specific tasks.

SDG&E has formed a consortium to fund and operate the Heber Binary Project. The funding contributions and ownership interests of the six participants are:

<u>Participant</u>	<u>Funding</u>	<u>Ownership</u>
Department of Energy	50.0%	---
Electric Power Research Institute	10.0%	---
San Diego Gas & Electric	32.8%	86.3%
Imperial Irrigation District	4.0%	10.5%
Department of Water Resources	1.2%	3.2%
Southern California Edison	2.0%	---

SDG&E is responsible for managing the Project, including its licensing and environmental effort, design, construction, start-up, and demonstration. We are managing the Project to the maximum extent possible as if it were a commercial power plant. In this way, we will have a good chance of completing the Project on schedule and with a greater likelihood of commercial success. Figure 3 shows the Project Organization.

Figure 3 Heber Binary Project Organization

Sponsors' Management Committee

Executive control of the Project rests with the Sponsors' Management Committee, which is comprised of representatives from SDG&E, DOE, EPRI, DWR, IID, and SCE. The chairman of this Committee is SDG&E's Vice President of Engineering. The Sponsors' Management Committee's charter is to successfully execute the Project in accordance with the agreements between the participants. The Committee oversees the Heber Binary Project as a business endeavor and provides management-by-exception resolution of technical and business problems outside of the scope of the DOE Cooperative Agreement, or those referred to it by the SDG&E Project Manager.

Sponsors' Technical Committee

Supporting the Project is the Sponsors' Technical Committee, which is chaired by the SDG&E Project Manager. The role of this Committee is one of support to the Sponsors' Management Committee and the SDG&E Project Manager for the resolution of technical issues. Membership consists of one representative from DOE, EPRI, and each participating utility. Technical consultants in the geothermal field are called upon as necessary to assist the Committee.

SDG&E Project Manager

The SDG&E Project Manager reports directly to the Sponsors' Management Committee, and is 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.

The SDG&E Project Manager has complete freedom to allocate his resources to meet Project needs and he may take any other actions he deems appropriate to fulfill Project goals, so long as those actions are consistent with the operating policies and procedures of the participating companies and the DOE Cooperative Agreement.

IV. DOE/SDG&E COOPERATIVE AGREEMENT

Summary

The Cooperative Agreement differs from other more conventional contracts used by DOE to fund projects. It recognizes that the Heber Binary Project is a partnership, with the private sector bearing a significant part of the risks. It permits the Project to be managed by the private sector with minimal burden on DOE.

The goal of government involvement should be to advance the time when the binary cycle will be available for commercial use. This goal can be achieved with the Heber Binary Project because the private sector has a large financial interest in the Project and, consequently, a great incentive to achieve success.

Some of the key features of the Cooperative Agreement that are unique include:

- A revenue sharing provision which will return to DOE the government's contribution if the power plant can be operated as a commercial facility.
- A ceiling on government financial exposure.
- Provisions for the broad dissemination of data from the Project to industry.
- The development of data and information for DOE, which are important to the realization of national energy goals.

V. THE HEBER RESERVOIR

Summary

Chevron Resources Company has estimated that the Heber reservoir has enough heat to support more than 500 megawatts of electric generating capacity for 30 years. This estimate has been confirmed by an independent reservoir evaluation performed by EPRI. Although actual operating experience is required to confirm the field's total capacity, our assessment indicates that there is a high probability that the total capacity is in the range of 500 megawatts.

The Heber reservoir has been subjected to extensive evaluation. Geophysical surveys, well drilling, well testing, and reservoir evaluations have been completed. Fifteen exploratory wells have been drilled in the area, the average depth being 5,500 feet and the deepest 9,700 feet. A northwest by southeast cross-section of the reservoir is shown in Figure 4.

Figure 4 NW-SE Temperature Cross-Section of the Heber Unit Area

The reservoir covers an area of approximately 7,400 acres, with brine temperatures up to 375°F. The brine is contained within porous and permeable sediments and has a total dissolved solids content of 14,000 ppm. No impediments to flow have been observed in detailed reservoir testing.

The development plan for the reservoir involves central production islands over the center of the heat anomaly and injection islands along its periphery. Cooled brine that is returned to the reservoir would sweep hot brine to the central producing wells to maintain reservoir pressure. The reservoir has about 75 percent of its heat contained in the rock grains and about 25 percent of its heat is contained in the geothermal brine. Central production and peripheral injection well islands allow the injected brine to contact the hot rock grains, thereby extracting and sweeping a larger fraction of the reservoir heat. The distance between the injecting and producing well islands also minimizes the risk of cold brine breakthrough into the producing wells during the 30-year life of the power plant. Figure 5 shows the relationship between the production and injection islands.

Downhole pumps will be used in the production wells of the Heber Binary Project. Since downhole pumps are expected to be required by nearly all low- and moderate-temperature reservoirs, the Heber Binary Project will be representative of the technology necessary to produce these reservoirs. The pump design is expected to be an adaptation of the shaft-driven pump. This type of pump has already been used at several geothermal reservoirs. However, other pump designs are currently undergoing test and development and will be reviewed before the type to be used in the Project is finally specified.

**Figure 5 Heber Binary Project Brine Pipeline Route
from Power Plant to Injection Island**

VI. COOLING WATER

Summary

Long-term, assured supplies of cooling water have been acquired by SDG&E. Three supplies are available--an initial supply of irrigation water, a primary supply of wastewater, and an emergency supply of irrigation water. This multiplicity of sources ensures the power plant will have enough water to sustain operation, even during periods of general water shortage.

The characteristics, terms, and conditions of these three supplies are:

- Initial supply consists of 6,000 acre-feet per year of agricultural irrigation water withdrawn from the Colorado River. The term for use of this water is five years and commences with the initial start-up of the power plant. This supply was secured by a contract between SDG&E and the Imperial Irrigation District, which was signed in October 1979.
- Primary supply consists of 6,000 acre-feet per year from two wastewater sources--the New River and agricultural drains. The term for this primary supply is the operational life of the plant following the initial five years. SDG&E has acquired access to its primary supply by the contract mentioned above and by an appropriation permitting the withdrawal of water from the New River. The appropriation was granted by the California State Water Resources Control Board in September 1980.
- Emergency supply consists of 6,000 acre-feet per year of agricultural irrigation water made available to the plant for any period during which the primary supply of drain water is unavailable. The same contract with IID for initial and primary supplies of water has secured the emergency supply.

VII. LICENSING AND PERMITS

Summary

Federal, State, and local governmental agency regulations have been complied with and all approvals and permits required at this time have been obtained. Additional permits will be obtained prior to the start of construction and the demonstration period.

Approval of Federal Agencies

An Environmental Assessment was prepared by the Oak Ridge National Laboratory for DOE. The final report was approved in October 1980.

The final report of the U. S. Water Resources Council was completed in September 1980. It is an assessment of water requirements and water supply availability for the Project.

Approval of State Agencies

The California Energy Commission (CEC) has the authority to approve siting for all thermal power plants. However, their jurisdiction is limited to plants with a net generating capacity of 50 Mw or more. Since the Heber Binary Plant has an average net generating capacity of 45 Mw, approval by the CEC is not required.

Construction of a new power plant also requires a Certificate of Public Convenience and Necessity from the California Public Utilities Commission (CPUC). The CPUC has limited its review of such facilities to those exceeding 50 Mw net. Therefore, the plant is exempt from the CPUC certificate requirement.

Approval of Local Agencies

Draft and Final Environmental Impact Reports (EIR's) assessing the full 500 Mw of development on the Heber reservoir, including the Heber Binary Project, were prepared by Imperial County as the lead agency. The Final EIR was certified by the Imperial County Board of

Supervisors on January 22, 1980; a Conditional Use Permit (CUP) to construct and operate the power plant was also granted at the same time.

Permits Obtained

The Imperial County Board of Supervisors has issued the following permits for the Heber Binary Project.

- A zone change for Geothermal (G) Overlay Zone of 7,320 acres on the Heber reservoir.
- A Conditional Use Permit to construct and operate the necessary facilities to extract, transport, and inject the geothermal fluid.
- A Conditional Use Permit to construct and operate a binary cycle, geothermal demonstration power plant.

Permits to be Obtained

The following permits will be obtained:

- Permits from the Imperial County Air Pollution Control District for Authority to Construct and Permit to Operate.
- A National Pollutant Discharge Elimination System Permit from the California Regional Water Quality Control Board-Colorado River Basin Region.
- A Building and Grading Permit from the Chief Building Inspector of the Imperial County Department of Public Works.
- Health and safety approvals from the Environmental Health Division of the Imperial County Health Department and from the Imperial County Fire Marshall.

- Easement and right-of-way agreements from the Imperial County Road Department for access roads with ingress/egress from a county road.
- An encroachment agreement for construction of facilities to deliver water to the plant from the Imperial Irrigation District.

VIII. ENGINEERING AND PROCUREMENT

Summary

The Project schedule has an elapsed time of 82 months. The demonstration period will commence in April 1985 and the final report issued by July 1987. Engineering is proceeding with major emphasis on the three major systems: brine, hydrocarbon, and cooling water. Major procurements will start with the purchase of the turbine generator in January 1982 and will be complete by July 1982. Work is also proceeding on an independent evaluation of the availability of the power plant and on the scoping of the data acquisition effort. The construction manager has been selected and the contract is planned for execution in the near future.

Schedule

The Project term is 82 months. It began with the execution of the Cooperative Agreement between DOE and SDG&E in September 1980, and will end three months after a two-year demonstration period. Figure 6 depicts the Project Schedule.

Engineering

Fluor Power Services, Inc. (FPS) of Irvine, California, was retained in late 1980 for the design of the Plant.

Fluor's initial efforts have centered on the development of the Project Design Guide and the definition of the power cycle. Incorporated in the Design Guide was the Master Schedule, as well as conceptualized designs of the major and minor systems that go into making up the entire plant. The Design Guide is updated quarterly and serves as the basis for the design of all systems. Much of the preliminary power cycle engineering focused on verification of the work done in the previous studies. The most notable result of these earlier studies was the optimization of the working fluid, and the

Figure 6 Heber Binary Project Schedule

subsequent establishment of the turbine inlet conditions. The Heber power cycle is based on a working fluid of a 90/10 mol percent mixture of isobutane and isopentane, and has turbine inlet conditions of 305°F and 575 psia.

In conjunction with the work being done on the conceptual design, FPS conducted a study on the advantages of allowing the plant output to vary with the cooling tower performance. Rather than fix the condenser pressure, and consequently the gross plant output, the study showed a significant increase in plant efficiency by taking advantage of the varying heat sink temperature available at the site. Historical data showed that the wet bulb temperature at the site would vary between 55°F and 80°F, which would correspondingly vary the temperature of the water in the cooling tower basin. As the cooling water temperature declined, the condenser pressure would likewise decline, allowing the turbine to extract more energy from the hydrocarbon for a given set of inlet conditions.

In addition to the efforts to improve the efficiency of the power cycle, emphasis was placed on improving the performance of the brine system within the constraints established by the heat supplier. Since the brine return pumps, which supply the necessary pressure for reinjection of the brine, had to be designed to accommodate both plugged and unplugged injection well conditions (a difference of 180 psi), FPS conducted a study on the economics of variable speed pumps. The study evaluated a variable frequency motor drive, a hydraulic coupling, and a constant speed motor, and concluded that the reduced operating costs of the variable speed drive more than offset the higher initial capital costs.

As the culmination of the conceptual design phase, FPS has issued preliminary Piping and Instrumentation Drawings (P&ID's) on the major and most of the minor plant systems. FPS will be issuing a second iteration of the P&ID's in December 1981 to show the results of the recent design changes. The next issue of the P&ID's, which

is scheduled to occur in July 1982, will be those "approved for design."

System Description

The binary cycle is made up of three major systems: the brine system, the hydrocarbon system, and the cooling water system. These three major systems are shown schematically in Figure 7, the plant process flow diagram.

The major components of the brine system are the brine/hydrocarbon heat exchangers, the brine return pumps, and the piping network necessary to transfer the brine from the production island through the heat exchangers and back to the injection island. The production island, which abuts the plant boundary, will consist of about 13 wells, each with its own downhole pump. Brine will be produced at a pressure high enough to prevent flashing, and will cross the plant boundary in an insulated 30-inch line. Heat is transferred to the working fluid in two parallel trains of three heat exchangers, with the brine on the tube side and the hydrocarbon on the shell side. Downstream of the heat exchangers are three 50% variable speed brine return pumps, which provide the necessary pressure for reinjection of the brine at the injection island located 2.25 miles from the plant. A bypass line is provided around the heat exchangers for use primarily during start-up and shutdowns. The plant has been conservatively sized to accommodate an expected decrease in reservoir temperature from 360°F to 338°F.

The hydrocarbon system, containing the working fluid and the majority of major plant equipment, is the most important of the three major systems. Two sets of pumps, the condensate pumps and the booster pumps, operating in series, raise the hydrocarbon from condenser pressure to a pressure necessary to maintain the turbine inlet condition of 575 psia. The two condensers feed a common hotwell, which provides the suction supply for two parallel trains of three 25% condensate pumps. The condensate pumps feed the four 33% hydrocarbon booster pumps, which raise the hydrocarbon to its final pressure. The brine/hydrocarbon heat exchangers then raise the temperature of the liquid hydrocarbon to superheated conditions at 305°F. A knockout drum is provided downstream of the heat exchangers to ensure no liquids reach the turbine inlet. Following expansion through the turbine, the hydrocarbon is exhausted into the two condensers, which are configured with the hydrocarbon on the shell side and the cooling water on the tube side. The common condenser hotwell is sized large enough to also serve as an accumulator for the hydrocarbon system. To ensure that a minimum brine return temperature of 150°F is maintained, a small amount of hydrocarbon can be bypassed around the first heat exchanger of each train. A bypass line is also provided around the turbine to facilitate process start-up and shutdown.

The cooling water system consists primarily of the cooling towers, the cooling water pumps, and the condensers. Ten induced draft, counterflow cooling towers provide the means for rejecting heat to the ambient surroundings. Three 50% cooling water pumps take suction from the common cooling tower basin and provide the necessary pressure to flow cooling water through the condensers and back to the top of the cooling towers. Makeup water for the towers is desilted in settling ponds and treated with an algaecide, a corrosion inhibitor, and sulphuric acid for pH control. Cooling tower blowdown is discharged to a nearby agricultural runoff water drain. The towers also provide cooling water for a closed loop service water system.

Other Activities

An availability enhancement program was implemented during the initial stages of engineering and design. Pickard, Lowe and Garrick, Inc. (PL&G) of Irvine, California, was selected as the subcontractor to implement this program. The availability analyses conducted by PL&G are performed in parallel with the engineering work, and are provided as design input to FPS, who makes the final decision on their incorporation into the design. PL&G has developed target availabilities for the plant and plant subsystems, performed cost-benefit studies on alternate configurations of systems in the conceptual design, made an assessment of the plant availability based on the preliminary P&ID's, and provided availability related input to the major equipment specifications. As the design progresses, PL&G will continue to update their assessed plant availability as actual pieces of equipment are purchased, and they will develop a program for the collection of availability related data once the plant goes into service.

The other major on-going engineering related activity is the development of a plant Data Acquisition System (DAS). The proposed system will interface with the plant instrument and control (I&C) system, and will provide a permanent record of plant process parameters, which will be used to determine plant performance and aid in the design of future binary cycle plants. SDG&E has taken the lead role in defining the DAS requirements through the establishment of a DAS Committee. The Committee has established the list of plant parameters to be recorded, and has defined the data output medium and data sampling rate requirements.

Procurement

A major milestone in the procurement process was reached in mid-October 1981 with the receipt of the turbine/generator quotations. Participating in the bidding were General Electric Company, Rotoflow Corporation, and United Technologies/Elliott. The generators quoted by the three turbine vendors were manufactured by General Electric, Electric Machinery, and Westinghouse, respectively. The commercial

and technical evaluation of the proposals is currently being conducted, and an award is expected in January 1982. The value of the contract will be in the vicinity of \$5.5 million.

The other major process components currently out for quotation are the brine/hydrocarbon heat exchangers and the hydrocarbon condensers. Six equipment fabricators are involved in each of these bids, which are due back at the beginning of December 1981. The contract award for these components is expected in February 1982.

The following shows the major equipment procurement schedule and estimated contract values.

<u>Item</u>	<u>P.O. Issued</u>	<u>Estimate</u>
Turbine Generator	January 1982	\$5,500,000
Brine/Hydrocarbon Heat Exchangers	February 1982	2,300,000
Hydrocarbon Condensers	February 1982	1,600,000
Hydrocarbon Condensate Pumps	February 1982	600,000
Hydrocarbon Booster Pumps	February 1982	1,100,000
Major Storage Vessels	March 1982	150,000
Brine Return Pumps	March 1982	800,000
Circulating Water Pumps	February 1982	1,100,000
Cooling Tower	April 1982	2,900,000
Gantry Crane (100-ton capacity estimate)	March 1982	175,000
Air Compressors	February 1982	50,000
Main Transformer	March 1982	300,000
Switchyard Equipment	May 1982	150,000
Main Control Panel	June 1982	150,000
Control Valves	May 1982	600,000

The other major Project procurement activity deals with the award of a contract for construction management services. The construction manager will review the engineering design for constructability, divide the construction work into manageable packages, issue bids for lump-sum proposals, evaluate the quotes, and make recommendations for contract award. During the construction, the construction manager will monitor the subcontractors' work, provide reports on progress, and turn over finished construction to the SDG&E start-up team. Dravo Utility Constructors, Inc. (DUCI) was selected for award, negotiations are essentially complete, and execution of an agreement is expected in December 1981.

IX. COSTS, COMMITMENTS, AND EXPENDITURES

Costs

The current estimate of shareable costs for the Heber Binary Project is shown below:

Environmental Studies and Permits	\$ 258,000
Engineering Design	12,214,000
Equipment and Construction	64,726,000
Start-up	3,423,000
Project Management	<u>3,560,000</u>
Subtotal	\$ 84,181,000
Demonstration (2 years)	<u>38,610,000</u>
Total	\$122,791,000

These costs are escalated to the year they are incurred. They do not include costs which, in accordance with the Cooperative Agreement, would be 100 percent funded by the DOE. Such costs would include DOE Project Office costs and any additional data acquisition and dissemination effort required by the DOE.

A definitive cost estimate (plus or minus 10 percent) will be prepared in mid-1982. It will be the basis for decisions by the Participants to proceed. In addition, it will lead to modification of the Cooperative Agreement, which would extend it to the end of the Project.

Commitments

The following Project commitments will be in place by December 31, 1981:

Fluor Power Services	Architect/Engineer	\$5,758,536
Fugro, Inc./Ertec Western	Geotechnical Services	83,488
Pickard, Lowe & Garrick	Availability Engineering	446,540
John E. Howard	New River Study	2,000
Woodward-Clyde Consultants	New River Temperature and Monitoring Data Acquisition	719
Bakers Maintenance	Air Conditioner for Met Tower	700
John D. Hess Testing	Groundwater Observation Wells	1,160
Dravo Utility Constructors	Construction Management	<u>2,958,314</u>
Total		\$9,251,457

Expenditures

Total Project expenditures through October 1981 are \$1,921,205.