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**REGIONAL SYSTEMS DEVELOPMENT FOR GEOTHERMAL ENERGY RESOURCES
PACIFIC REGION (CALIFORNIA AND HAWAII)**

**TASK 2 - REGIONAL PROGRAM MONITORING
AND PROGRESS EVALUATION**

TOPICAL REPORT

19 MARCH 1979

**Prepared for
Department of Energy
Division of Geothermal Energy
Washington, D.C.**

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PREFACE

This Topical Report for Task 2 was prepared by System Development Corporation, Santa Monica, California (the Regional Systems Development Contractor for Geothermal Energy Resources in California and Hawaii), in partial fulfillment of the terms of Contract DE-AC03-78ET-28432 with the Department of Energy, Division of Geothermal Energy.*

On January 4, 1979, a draft of this report was submitted for review and comments to DOE, the developers, and the utilities involved. Their prompt response is very much appreciated. It has since been updated and refined as a result of the comments received.

*Formerly Contract EG-78-C-03-1530

FOREWORD

Our contract with the Federal Department of Energy (which designated System Development Corporation as a Regional Systems Development Contractor for electrical power generation applications) was centered upon three basic tasks that were directed toward "Regional Systems Development for Geothermal Energy Resources in the Pacific Region (California and Hawaii)."

Task 1 - Development of Regional Geothermal Energy Implementation Plans

Task 2 - Regional Program Monitoring and Progress Evaluation

Task 3 - Evaluation of the Water Resources Regionally Available for Geothermal Energy Development

These tasks were intimately interrelated and required a number of iterations both individually among the elements of each task and severally among the tasks. In developing implementation plans under Task 1, we needed to establish the status of existing projects (determined in Task 2) and to be aware of the available water resources (assessed in Task 3). In turn, the evaluation of existing projects and the analysis of water availability was heavily influenced by the plans, i.e., the type of power plant and the rate at which power would be brought on-line. An overview of the tasks is presented in Figure F-1.

The tangible results of these tasks, and the recommendations that we developed, were reviewed with government and industry. Their comments and suggestions have been incorporated into our final contractual products. In a very real sense, we have served to "cross-pollinate" the industry and governmental agencies at several levels by prudently facilitating the exchange of information and by discussing problems and potential (or realized) solutions with many individuals.

TASK 1
Implementation
Plans

TASK 2
Regional Program
Monitoring and
Progress Evaluation

TASK 3
Water Resources
Availability
Evaluation

ABSTRACT

We undertook three major tasks under DOE Contract DE-AC03-78ET-28432. They all relate exclusively to the utilization of geothermal energy resources for the generation of electrical power in California and Hawaii. Task 2 is presented in this topical report. (Separate topical reports have been prepared for Tasks 1 and 3.)

Task 1 - Development of Implementation Plans for the Commercialization of Geothermal Resources.

Eleven implementation plans were prepared. They represent some 21 reservoir-site developments and 48 geothermal power plant developments. The plans consist of three integrated elements: (1) a bar-chart schedule that depicts interdependencies among activities and shows significant milestones on the path from initial exploration to power on-line, (2) task descriptions, and (3) the responsible performers. During the preparation of the implementation plans, the tasks required for resource development at each KGRA were defined on a generalized work breakdown structure (WBS) diagram. A generalized WBS dictionary (task descriptions) was also compiled. In addition, a specific WBS for each KGRA was prepared in a tabular and indented format. The tasks formed the basis for the schedular activities. Institutional responsibilities, based upon the WBS, were identified and are also shown on the tabular WBS. In this manner, implementation plans evolved whose schedular, task, and responsibility elements were integrated with one another.

Each plan is based in large measure upon discussions with developers and utilities, and with the governmental entities with which they must interact. Based upon our analysis of all the acquired data and the historical track records, we have made judgments with respect to power on-line dates and certain activities that are not necessarily consonant with the stated opinions or plans of each specific interviewee. However, the implementation plans have been reviewed with the various parties concerned and do represent a reasonable consensus for the near-term (to 1990).

In order to provide logically consistent time estimates, and a reasonable basis for comparison, schedule modules were developed for some recurring activities which are essentially common to all KGRAs. These modules are effectively lower tier schedules which are presented in the form of flow charts that define responsibilities and specify elapsed times. The majority of the modules are permit-specific since the regulatory requirements usually constitute the driving process and are widely relevant to all the KGRAs. In their application to the implementation plans, some adjustment to the time spans was made on occasion to accommodate local (site-unique) peculiarities.

In the preparation of multiple plant schedules for a given KGRA, the interactive effects of power development on the ancillary resources of the area were considered so that interfaces and constraining situations would be identified. Within Imperial County, this process was taken one step farther to include the influence that development at the several close-lying KGRAs would have upon one another.

A set of recommendations for the accelerated development of geothermal energy resources was prepared and the potential implementors were suggested.

Task 2 - Regional Program Monitoring and Progress Evaluation.

All the objectives have been met through personal contacts and the review of data. They are as follows:

- a. To determine the existing status of power plant projects and future plans.
- b. To identify major problem areas for each project (technical, financial, regulatory) that are affecting progress.
- c. To analyze the data and to develop recommendations directed toward resolving problems.

The results have been presented in a tabular summary format that is accompanied by explanatory text covering 25 projects.

Task 3 - Water Resources Evaluation

The fundamental objective of the water resources analysis was to assess the availability of surface and ground water for potential use as power plant make-up water in the major geothermal areas of California. The analysis was concentrated on identifying the major sources of surface and ground water, potential limitations on the usage of this water, and the resulting constraints on potentially developable electrical power in each geothermal resource area. If data on water resources were not available or sufficient for a given locale to complete this analysis, procurement specifications were prepared that can be used by DOE at some future date to acquire the necessary information.

Analyses were completed for 11 major geothermal areas in California: four in the Imperial Valley, Coso, Mono-Long Valley, Geysers-Calistoga, Surprise Valley, Glass Mountain, Wendel Amedee, and Lassen. The lack of complete data on resource characteristics and ultimate reservoir capacity precluded an analysis of constraints for areas not designated as a KGRA. One area in Hawaii, the Puna district, was also included in the analysis.

The water requirements for representative types of energy conversion processes were developed using a case study approach. Cooling water requirements for each type of energy conversion process were estimated based upon a specific existing or proposed type of geothermal power plant. The make-up water requirements for each type of conversion process at each resource location were then estimated as a basis for analyzing any constraints on the megawatts which potentially could be developed.

Clearly, the activities (and outputs) of the three contractual tasks are interrelated and interdependent. The results were in fact integrated into a self-consistent product.

1.0 INTRODUCTION AND RECOMMENDATIONS

1.1 INTRODUCTION

This report summarizes the work done on Task 2: Regional Program Monitoring and Progress Evaluation for California and Hawaii. The specific objectives of Task 2 were as follows:

- a. To determine the existing status of power plant projects and future plans.
- b. To identify the major problem areas for each project (technical, financial and regulatory) which are holding up progress.
- c. To analyze the data and make recommendations to DOE regarding the action which could be taken to alleviate the problems.

1.2 RECOMMENDATIONS

Table 1-1 summarizes the major problems for each of the planned power plants and for the KGRAs where power plants have not yet been planned. It lists the KGRAs, the names of the operators involved for each power plant project, the figure number where further details of the problem and recommendations are given, the power rating and scheduled on-line date, the major problem(s) affecting the success of the project and the identification number of the recommendations presented in Table 1-2.

Table 1-2 summarizes the eight types of problems identified, shows the number of plants affected by each and outlines the recommendations to alleviate these problems. Table 1-2 lists these problems in the order of decreasing number of projects affected as follows: (1) inadequate funds, (2) insufficient well flow rate, (3) H₂S abatement requirements, (4) downhole pump failures, (5) scaling and reinjection problems, (6) public opposition to the new transmission lines required, (7) permitting delays, and (8) volcanic activity hazard.

KGRA	OPERATOR OF WELLS/POWER PLANT	REFERENCE FIGURE	MWe/YEAR	MAJOR PROBLEM	RECOMMENDATIONS (See Table 1-2)
1. Heber	Chevron/SDGE	2-7	45/Canc.	F Obtaining contributors for 50% of cost	1, 4
	Chevron/SCE	2-8	45/83	T Low pressure in steam separator	
2. Salton Sea	Magma/SDGE	2-15	50/83	F Negotiations with steam supplier	1
	Union/SCE	2-16	10/82	T Potential scaling and reinjection problems	5
	McCulloch/DWR	2-17A	55/84	T Potential scaling and reinjection problems	5
3. East Mesa	Magma/Magma	2-21	11/79	T Solving downhole pump problems	4
	RGI/SDGE	2-26	10/80	F Funding of power plant, GLGP approvals	1
4. Brawley	Union/SCE	2-27	10/80	T Solving scaling problems,	5
	McCulloch/DWR	2-28A	55/83	T Solving low well flow rate problem	3,4
5. Westmorland	RGI/TBD	2-29	50/82	F Funding of power plant, GLGP approvals	1
6. Cose	TBD by RFP	2-31	110/86	T Solving low well flow rate problem	3,4
7. Long Valley	Magma/SCE	2-33	60*/83	F Improving economics of heating plant	1
8. Geysers-H ₂ O	Phillips/TBD	2-35	None	T Obtaining satisfactory well performance	3
9. Geysers-Steam	Union/PGE	2-38A	1162/34	T Solving air quality, transmission line problems	2,6
	Aminoil/PGE	2-39	335/83	T Solving air quality, transmission line problems	2,6
	Thermogenics/PGE	2-40A	55/79	T Solving air quality problems	2
	Shell/NCPA	2-41	110/82	T Solving air quality problems	2
	GKI/DWR	2-42A	55/83	None	
	McCulloch/DWR	2-43	55/83	None	
10. Wendell-Amedee	Geoproducs/DWR	2-45	55/83	F DXF cos. sharing is required	1
11. Lassen	Phillips, Union/TBD	2-47	None	T Obtaining satisfactory well performance	3
12. Glass Mtn.	Several lease applicants	2-49	None	P Reducing delays in EIR and ES for leasing	7
13. Surprise Valley	Magma, Gulf/TBD	2-51	None	T Obtaining satisfactory well performance	3
14. Diablo	None	2-53	None	Not a KGRA	-
15. Hawaii	HA/HELCO	2-55	3/80	T Possible volcanic activity	8

NOTE: F denotes funding problem, T denotes technical, P denotes permitting.

*Thermal Power

Table 1-2. Recommendations to DOE

<u>TYPE OF PROBLEM</u>	<u>CLASS*</u>	<u>PLANTS AFFECTED</u>	<u>RECOMMENDATION TO DOE</u>
1. Insufficient Funds	F	6	Participate in funding or sponsor reservoir insurance. Streamline GLGP approvals (Fig. 2-7, 2-26).
2. Low well flow rate	T	5	Item (4) and funding R & D of well stimulation means.
3. H ₂ S abatement	T	4	Continue to fund the tests of EIC CuSO ₄ process. Demonstrate feasibility of H ₂ O ₂ and NaOH injection in the steam to reduce emissions during venting. Continue investigation of treatment of condensate by iron oxide, H ₂ O ₂ and NaOH.
4. Downhole pump bearing failures	T	4	Fund an R & D program to solve these problems (Fig 2-21).
5. Scaling and rein- jection problems	T	3	Continue 50% funding of GLEF** until maintenance costs due to scaling of plant and wells are demonstrated to be acceptable (Fig. 2-15).
6. Public opposition to new transmission lines	T	2	Select from alternate corridors. Investigate means of increasing capacity of existing lines (Fig. 2-38A).
7. Permitting delays	P	1	Expedite action by Federal, State and local government agencies.
8. Volcanic hazard	T	1	Investigate "defensive" plant design techniques and alternate sites.

* F denotes funding, T technical, P permitting

** Geothermal Loop Experimental Facility

Table 1-2. Recommendations to DOE

Of the three classes of problems - funding, technical and permitting - it can be seen that the problem affecting the most plants is inadequate funds. Most of the problems are technical, but even these are basically financial due to their economic impact. All of the problems are discussed in more detail below.

1.2.1 Inadequate funds.

The difficulties that some field developers and/or utilities (particularly the smaller ones) are experiencing in obtaining the funding necessary to develop the hot water geothermal reservoirs are directly related to the risks associated with reliably generating power at competitive rates from an essentially unproven technology. The higher than normal risk prevails notwithstanding the fact that in other countries hot water reservoir plants have been in operation for several years. For example, the 75 MWe power plant at Cerro Prieto, Mexico has been in operation for over five years and has demonstrated an average availability* of 90% during 1977 at a power cost of eight mills/KW-hr (Ref. 128). However, environmental constraints are effectively non-existent (e.g., no requirements for H₂S abatement or reinjection) and the quality of this Mexican geothermal field is significantly better than the hydrothermal fields being considered for development in California. This resource exhibits low TDS (total dissolved solids are 25,000 ppm), pressures to 6000 psi and temperatures ranging to 600°F which is far above the California KGRAs, most of which have temperatures less than 400°F. (Only the Salton Sea, Brawley and Westmorland KGRAs have temperatures greater than 400°F, but the TDS at the Salton Sea KGRA are as high as 250,000 ppm).

There are several initiatives or courses of action that could be undertaken by DOE to reduce the perceived risk, enhance the price-competitive position of geothermally generated electricity in the marketplace, and accelerate its development. (Also see the Task 1 Topical Report). They are as follows:

*Availability, % = $(100)(\text{Operating Hours})/(\text{Period Hours})$,
where Period Hours are usually based upon one year.

- a. Cost sharing by DOE with the developer and utility when required for the first power plant at each KGRA for those cases where significant site-specific differences exist among the KGRAs.
- b. Sponsoring of reservoir life insurance, or other risk-ameliorating initiatives such as the refund of lease payments in the event that the reservoir fails to produce.
- c. Advocating the passage of more liberal tax incentives in order to attract venture capital (further improvements over those enacted by Congress in October 1978, which gave geothermal energy the same tax advantages as other energy sources).
- d. Shortening the time required for obtaining funds under the Geothermal Loan Guarantee Program.

1.2.2 Insufficient Well Flow Rates

This is a major problem for five of the projects listed. It is recommended that DOE fund an R&D program so that effective means of increasing the natural flow rate by well stimulation can be defined.

1.2.3 H₂S Abatement Requirements

The California ambient air quality standard for H₂S is 30 ppb. The first ten units at the Geysers were not provided with any means of H₂S control. An iron hydroxide system was tested on Unit 11 and was about 70% efficient. Plants 1 through 12 will be retrofitted with a system using iron oxide + NaOH and possibly H₂O₂ to treat the condensate. Plants 13 to 15 will use the Stretford process to reduce the H₂S in the noncondensable gas stream to less than 10 ppm. However, the overall plant abatement is expected to be 78 to 92% due to the amount which escapes from the condensate. It may therefore be necessary to treat the condensate with iron oxide, NaOH and H₂O₂ in addition. Emissions during venting operations continue to be a problem and so do the requirements for expensive H₂S monitoring to assess conformance to air quality standards. The CuSO₄ Scrubbing Process developed by EIC removes 99% of the H₂S from the steam at the turbine inlet and has the potential for being the lowest cost method.

Recommendations to DOE are as follows:

- a. Continue to fund the tests of the CuSO_4 equipment. This is a \$2.1M program scheduled for six months of tests on unit #7 starting in April or May, 1979.
- b. Continue to encourage the investigation by PG&E of the effectiveness of using iron oxide, NaOH and H_2O_2 to treat the condensate.
- c. Demonstrate the feasibility of H_2O_2 and NaOH injection in the steam to reduce emissions during venting.
- d. Pursue an H_2S abatement program for liquid dominated geothermal reservoir plants.

1.2.4 Downhole Pump Bearing Failures

Downhole pumps are required for the Magma Power and RGI power plants at East Mesa and were to be used in the now cancelled SDG&E plant at Heber due to the low natural flow rate of the wells and to prevent flashing in the wells. Peerless 1200 GPM pumps, driven by an 800 foot long shaft from the surface, are used at the Magma Power plant. The shaft has bronze bearings every five feet and the bearings have been failing with a MTBF (mean time between failure) of only 30 to 45 days. It is very expensive to pull these pumps and shafting to replace the bearings. Assuming an 80% capacity factor* and a 12% discount rate, we estimate that this will increase the busbar cost by 3 to 4 mills/KW-hr for a 50 MWe plant (excluding the effect on plant capacity factor and the cost of spare wells required to compensate for that effect). We recommend that DOE fund an R&D program to improve the MTBF by an order of magnitude as downhole pumps are vital for the wells for the above plants and could alleviate the problem of low flow rate at other locations. R&D programs for testing and development of other pump systems (e.g., downhole submersible) are also recommended.

$$\text{*Capacity Factor, \%} = \frac{(100)(\text{Total Gross Power Generated, MW-hr})}{(\text{Period Hours})(\text{Maximum Dependable Capacity})}$$

where Period Hours are usually based upon one year.

1.2.5 Scaling and ReInjection Problems

Scale deposition in plant equipment, lines and reinjection wells is a problem at many hot water reservoirs and in particular at the Salton Sea where the TDS (total dissolved solids) is as high as 250,000 ppm. This increases the cost of power due to the deleterious effect on plant capacity factor, maintenance costs and well replacement costs. These problems are being solved at the GLEF (Geothermal Loop Experimental Facility), which is being operated by San Diego Gas and Electric at the Salton Sea, under a 50/50 cost sharing plan with DOE (Figure 2-12). For example:

- o The one mile long, ten-inch diameter reinjection line was scaling at an average rate of 37% loss in cross-sectional area per month. It cost \$50,000 to clean it with a high pressure water jet. It was then found that daily pigging with a wire brush pig at a cost of only \$900/month (Ref. 34) resulted in a permanent scale thickness of 3/8".
- o The injection well has been plugging due to suspended solids in the reinjected brine. A commercially available clarifier tank and dual media filter installed in the line are expected to reduce the suspended solids from over 300 ppm to less than 5 ppm.
- o The flash tanks and lines have been scaling at an average rate of 0.7"/month. The cost to clean the entire plant with a hydrojet every six weeks is estimated to be \$15,000. It is expected that it will be \$133,000/year for a 50 MWe plant (Ref. 36/A-12, 4-51) in which case the cleaning cost will be only .3 mills/KW-hr. (A redundant pair of flash tanks would be used to eliminate plant shutdown during cleaning).

It is recommended that DOE continue the 50% cost sharing of the GLEF until maintenance costs due to scaling and the reliability of injection are demonstrated to be acceptable for a 50 MWe plant. If this can be done at the Salton Sea, then it is likely that the problem would be solved for all the KGRAs as they all have lower TDS.

1.2.6 Public Opposition to New Transmission Lines

Transmission lines out of the Imperial Valley will be required by the time the first few 50 MWe geothermal plants come on line there as the Imperial Valley cannot use all the power it will generate. The Imperial Valley Action Plan Steering Committee has commissioned a study aimed at resolving the transmission line issue. We recommend that an action plan based upon the results of that study be formulated expeditiously, and implemented, so that additional major transmission line capacity is available for use by mid-1980.

This is also a problem for two of the new plants at the Geysers. PG&E has designated a number of alternative transmission corridors out of the Geysers area, and is awaiting a decision on them by the CERCDC California Energy Resources Conservation and Development Commission. We recommend that the CERCDC (with the support of the GRIPS Commission) move rapidly to resolve the immediate problem and undertake to develop a comprehensive transmission line plan for the Geysers.

1.2.7 Permitting Delays

This has been a problem for many plants, in particular the Geysers, but it appears to be clearing up there. It is currently a major problem at only one project - the Glass Mountain KGRA (Fig. 2-49). No geothermal wells have been drilled there yet but the Klamath National Forest Office has received 20 to 25 lease applications from potential geothermal developers. However, the ES (Environmental Statement) is not scheduled to be completed by that office and the BLM until 1980 and a decision to lease or not lease is scheduled for late 1980. It is recommended that action be taken to decrease the long time required for this decision to be made.

1.2.8 Volcanic Action Hazard at Puna, Hawaii

The well for the 3 MWe demonstration power plant scheduled to go on line here in 1980 (Fig. 2-55) is located on the rift in the east flank of Kilauea Volcano. HELCO (Hawaii Electric Light Company) is reluctant to locate a full scale commercial plant here, even if the demonstration plant is successful.

due to the possibility of a future eruption at the plant site. It is recommended that a study be made of the possibility of locating the plant one to two miles away from the rift, with a plant and well spacing design which would result in a high probability of survival for the plant and most of the wells. This suggestion is based on experience with geothermal plants in Iceland; in particular, one which was undamaged during a volcanic eruption only two miles away except for 2 out of 11 wells. Alternate sites should also be investigated. (Also See Section 2.1.20.)

2.0 TECHNICAL APPROACH

The approach used to attain the objectives of Task 2 is summarized in Figure 2-1. It basically consisted of making an initial visit to key personnel associated with each project to obtain the required information and then making a revisit to verify the data obtained and review the recommendations made by SDC. Prior to each initial visit, all available information on a given project was obtained from various sources and put in the form of a "workbook" encompassing the following individual sheets:

- a. General Information Summary showing all data elements required to evaluate the status of a planned or existing power plant.
- b. Key personnel contacted and relevant information about them.
- c. Plant Schedule.
- d. Plant Schematic Diagram.
- e. Plant Problem Area Summary.

The workbook enabled SDC personnel to become familiar with the project prior to a visit. It served to focus the interview on the information desired, identify information gaps and assure that all aspects were discussed.

The status of the Task 2 projects and visits is summarized in Figure 2-2. Initial visits were made to all of the power plant projects listed. Revisits were made to all but four projects. The latter visits were not necessary as all required information was obtained in feedback on the draft Topical Report sent to utilities and developers. All responded with updated information and, where necessary, corrections to the information shown. These revisions have been incorporated in this final report. It can be seen that an average of approximately two power plants per year is scheduled to come on line from 1978 to 1984 in addition to those at the Geysers. Information obtained regarding these power plant projects is summarized in the workbooks and discussed in detail in the next section.

Figure 2-1. Project Visit Methodology

KGRA	OPERATOR OF RESERVOIR/POWER PLANT	REFERENCE FIGURE	MWe/DATE	VISIT 1978	REVISIT 1978
1. Heber, Imp. Valley	Chevron/SDGE	2-3	45/cancelled	5/17	7/5
	Chevron/SCE	2-8	45/83	6/13	8/16
2. Salton Sea, Imp. Valley	Magma/SDGE	2-10	50/83	5/17	7/5
	Union/SCE	2-16	10/82	7/19	8/7
	McCulloch/DWR	2-17A	55/84	9/21	*
3. East Mesa, Imp. Valley	Magma/Magma	2-18	11/79	5/11	6/29
	RGI/SDGE	2-22	10/80, 48/81	5/15	6/12
4. Brawley, Imp. Valley	Union/SCE	2-27	10/80, 50/84	8/18	*
	McCulloch/DWR	2-28A	55/83	9/21	*
5. Westmorland, Imp. Valley	RGI/?	2-29	50/82	6/12	8/17
6. Coso, E. Sierra	NWC to issue RFP	2-31	10/81, 110/86	8/9	11/16
7. Long Valley, E. Sierra	Magma/SCE	2-33	60 MW _t /83	8/7	11/1
8. Geysers-Hot H ₂ O	Phillips, Borax/PGE	2-35	None Planned	9/1	-
9. Geysers-Steam	Union/PGE	2-37	502 on line +656/79-84	8/16	8/31
	Aminoil/PGE	2-39	355/79-83	8/31	10/25
	Thermogenics/PGE	2-40A	55/79		10/25
	Shell/NCPA	2-41	55/81 and 82	9/1	9/26
	GKI/DWR	2-42A	55/83	8/17	*
	McCulloch/DWR	2-43	55/83	8/17	9/21
10. Wendell-Amedee, N.E. CA.	Geoproduts/DWR	2-45	55/83	8/16	*
11. Lassen, N.E. CA.	Geysers Stm Co/1 Well '62 Phillips/1 Well '77	2-47	None Planned	-	-
12. Glass Mtn., N.E. CA.	No wells, no permit appl.	2-49	None Planned	-	-
13. Surprise Valley, N.E. CA.	Magma, Gulf Oil/7 Wells	2-51	None Planed	-	-
14. Diablo, Centr. Coast	No wells; not a KGRA	2-53	None Planned	-	-
15. Puna, Hawaii	State of Hi/HELCO	2-55	3-5/80	8/18	10/3

* Not necessary as all required information was obtained in review of Topical Report draft in Jan. 1979.

Figure 2-2. Status of Task 2 Power Plant Visits

2.1 TECHNICAL DISCUSSION

Figures 2-3 through 2-56 are the workbook sheets for all of the power plant projects in the order listed in Figure 2-2. They are discussed in more detail hereunder.

2.1.1 Heber/SDGE/45 MWe Power Plant

Figure 2-3 is a General Information Summary for this power plant which was planned to be a demonstration plant with 50% cost sharing by DOE. It was scheduled to go on line in June, 1981. However, a decision was made by DOE on 3 July 1978 to fund a demonstration plant in New Mexico instead. SDGE (San Diego Gas and Electric Co.) was unsuccessful in obtaining the remaining funds from other sources, so the project was cancelled at the end of 1978. Information is summarized on it in spite of this as it may be of interest to some and it also demonstrates a complete set of the kinds of information desired for all the planned power plants in California and Hawaii.

The type of workbook sheet shown in Figure 2-3 summarizes the information relative to the first power plant planned for a given KGRA. (Note that references are given in Appendix B for all the information appearing on the workbook sheets.) The title denotes that it was to be located in the Heber KGRA, that the primary developer (or, in this case, utility) was to be SDGE, the net power was to be 45 MWe and the information shown is as of January 11, 1979. The well field is being developed by Chevron. The power plant was to be designed and built by SDGE contractors and was to be operated by SDGE. A binary cycle (heat transfer from brine to isobutane) was to be used rather than flashed steam due to the fairly low bottom hole temperature of 360°F.

The additional information presented comes under the general headings of Permitting Status; Financial Data; Well Data; Reservoir Potential; Water Source, Transmission Line and Technical Status; and Major Problem areas. This information served as an input to Task 1 (Implementation Plan Development), together with the backup information shown in the accompanying figures.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u> (App. B)
SCHEDULED ON LINE DATE	6/81 IF DOE FUNDING HAD BEEN REC'D BY 6/78; CANCELLED AS OF 12/31/78	120
LOCATION	HEBER/IMPERIAL VALLEY, S. CA.	} 49
WELL FIELD/POWER PLANT OPERATOR	CHEVRON/SAN DIEGO GAS AND ELECTRIC	
CYCLE	BINARY	
PERMITTING-PLANT EIR STATUS	EIR (REF. 25) COMPLETED 3/78; CUP APPROVED 5/78	
FINANCIAL-COST	\$68M (\$50M FOR PLANT AND TRANSMIS. LINE +\$18M FOR WELLS)	35
FUNDING	SDGE - 77%, IID - 10%, LADWP - 10%, SCE - 1.5% of \$ 29M, EPRI AND OTHERS \$5.1M. ADDITIONAL \$34 M WAS REQUIRED	84 35
POWER COST, MILLS/KW _r	41-52 FOR 75% CAPACITY FACTOR, '77 DOLLARS	49
WELL DATA-NO. DRILLED	15 (2 PRODUCTION, 1 INJECTION EXTENSIVELY TESTED)	25/11-3,4
ADDITIONAL REQ'D FOR POWER PLANT	20 (13 PRODUCTION, 7 INJECTION); ABOVE ARE TOO FAR AWAY	25/11-9;49
BOTTOM HOLE T	360°F	25/11-22
FLOW RATE/WELL	1170 GPM; 585,000 lb/hr.	25/11-22
DISSOLVED SOLIDS	14,000 PPM	25/11-22
DEPTH, AVERAGE	5500 FT (1677 m).	25/11-3
RESERVOIR POTENTIAL	970 MWe, 400 - 500 MWe FOR 10K' DEEP WELLS	1/1-16,25/11-6
RESERVOIR PROVEN (30 YR)	500 (SDGE/CHEVRON)	35
WATER SOURCE STATUS	IMPERIAL IRRIGATION DISTRICT WAS TO SUPPLY FOR 5 YRS.	25/1-3, 45
TRANSMISSION LINE STATUS	EXISTING ADJACENT IID LINE WAS TO BE USED	25/IV-74
TECHNICAL STATUS	FLUOR PIONEER INC. WAS UNDER CONTRACT TO SDGE FOR DESIGN; TO BE COMPLETED BY MID '79; 2000 HRS. HE TESTS COMPLETED	120
TURBINE/GENERATOR STATUS	65 MW ISOBUTANE TURBINE WAS BEING DESIGNED	3/196

Figure 2-3. Heber/SDGE/45 MWe Power Plant General Information Summary (As of 1/11/79) (1 of 2)

ITEM
MAIN PROBLEM AREA

DATA
SOURCE OF THE ADDITIONAL FUNDING REQUIRED. ATTEMPTS
TO OBTAIN THIS HAVE BEEN UNSUCCESSFUL. SDGE SENT OUT
REQUESTS FOR PARTICIPATION TO 16 OTHER UTILITIES BUT
DUE TO LACK OF INTEREST THE PROJECT WAS CANCELLED 12/31/79.

REF/PAGE

84

15

Figure 2-3. Heber/SDGE/45 MWe Power Plant General Information Summary (As of 1/11/79)
(2 of 2)

Permitting Status - The EIR (Environmental Impact Report) was completed in March 1978. The CUP (Conditional Use Permit) for the power plant was approved in May 1978.

Financial Data - The total cost of the power plant and wells was to be \$68 million. Originally it was planned to be 50 percent funded by SDGE and others as shown in Figure 2-3 with the other 50 percent of the funding to be provided by DOE.

Since DOE chose not to participate SCE has reduced their contribution from 3 to 1.5%. EPRI planned to increase its funding substantially but not enough to continue the project. SDGE sent out requests for participation to 16 utilities throughout the southwest U.S. in an attempt to find sources of funding for the remaining cost but they have been unsuccessful so the project was cancelled at the end of 1978. A significant factor underlying SDGE's difficulties is that this is a first of a kind plant and there is a risk of low capacity factors or complete failure.

Well Data - A total of 15 wells have already been drilled and two production wells and one injection well have been extensively tested by Chevron. A total of 20 wells (13 production and 7 injection) would have been required for the plant. (The existing wells are too far away from the plant site to be used). Data are provided for the well parameters affecting the cost of the power, i.e., average temperature, flow rate, dissolved solids and well depth. Additional data on individual wells at Heber and other KGRAs in the Imperial Valley are given in Appendix A. The reservoir is considered by SDGE and Chevron to be proven for 500 MWe for 30 years. The rate of development will depend heavily upon the success of the first plant to be built there (now the one planned by SCE as discussed later)..

Water Source - The Imperial Irrigation District (IID) agreed to supply the required makeup water for the first five years of this plant's operation. After that, SDGE planned to use treated irrigation drainage water if tests of this approach are successful.

Name <u>Richard Swanson</u>	Phone <u>(714)232-4252</u>	Name <u>Mike Carroll</u>	Phone <u>(714)232-4252</u>
Organization Unit <u>San Diego Gas & Electric</u>		Organization Unit <u>SDGE</u>	
Title or Position <u>Geothermal Program Manager</u>		Title or Position <u>Project Manager</u>	
Specialty <u>Planning, Financial, Permitting and Supervision of SDGE Geothermal Program.</u>		Specialty <u>Technical for Heber Plant</u>	
Location <u>San Diego, 101 Ash St.</u>		Location <u>San Diego, 101 Ash St.</u>	
Visited <u>5/17/78 and 7/5/78</u>			
Name <u>Al Cooper</u>	Phone <u>(415)894-3825</u>	Name _____	Phone _____
Organization Unit <u>Chevron Resources</u>		Organization Unit _____	
Title or Position <u>Project Engineer, Heber Field</u>		Title or Position _____	
Specialty _____		Specialty _____	
Location <u>San Francisco</u>		Location _____	
Visited <u>9/1/78</u>			
Name <u>Chris Sharpenberg</u>	Phone <u>(714)352-8901</u>	Name _____	Phone _____
Organization Unit <u>Chevron Resources</u>		Organization Unit _____	
Title or Position _____		Title or Position _____	
Specialty <u>Well Testing</u>		Specialty _____	
Location <u>Heber, JD Jackson well test site</u>		Location _____	
Visited <u>5/9/78</u>			

Figure 2-4 Key Personnel Contacted, Heber/SDGE/45 Mw

OVERALL SCHEDULE HEBER DEMONSTRATION PLANT (45 MWe)

Figure 2-5. Overall Schedule, Heber Demonstration Plant

Transmission Line and Technical Status - SDGE planned to connect the plant to the existing adjacent IID transmission line and sell the power to IID. SDGE contracted with Fluor Pioneer for the design of the plant which was scheduled to be completed by mid-1979. The 65 MWe (gross power) isobutane turbine was being designed.

Major Problem Area - As noted above, the lack of adequate funding constituted the most serious impediment to the SDGE plan for a geothermal electric power plant at Heber.

Figure 2-4 identifies the key personnel associated with this power plant project and shows the dates on which they were visited. Other contacts were made with them by telephone.

A plant schedule was obtained from the plant operator whenever possible to serve as a starting point for the implementation plan (Task 1). Figure 2-5 shows such a schedule from the SDGE proposal for the demonstration plant, submitted to DOE in January 1978. The EIR and CUP (Conditional Use Permit) have been completed since then as shown. The signing of the DOE contract, which had been expected by July 1978, is shown delayed indefinitely, as is the on-line date.

Figure 2-6 shows the schematic diagram for the power plant. It can be seen that down-hole pumps were to be used to provide the required flow rates and prevent flashing in the well. The brine would pass through a heat exchanger where it would vaporize the isobutane which would expand through the turbine and would be condensed in a closed circuit. All the brine from the heat exchanger would have been reinjected to eliminate the problem of H_2S escape to the atmosphere. The brine, isobutane, and cooling systems are each separate and distinct fluid circuits.

Figure 2-7 summarizes information regarding the main problem area for this power plant, namely a financial problem. It also presents a recommendation to DOE regarding action that could be taken to alleviate the problem.

Figure 2-6. Schematic Diagram of Heber/SDGE/45 MWe Power Plant

MAJOR PROBLEM AREA: Financial

- A proposal was submitted to DOE in January 1978 in response to a PON for cost sharing of a demonstration plant.
- A decision was made by DOE on 7/3/78 to fund only one demo plant - in New Mexico.
- SDGE cannot fund the Heber plant without help from DOE due to the higher than normal risk for a demo plant.

RECOMMENDATION TO DOE

1. Participate in funding of the Heber demonstration plant in addition to the New Mexico demonstration plant.

Figure 2-7. Heber/SDGE/45MWe Power Plant Problem Areas Summary (As of 1/11/79)

2.1.2 Heber/SCE/45 MWe Power Plant

Figures 2-8 and 2-9 present the General Information Summary and Key Personnel Contacted for this plant.

Progress on this plant is considerably behind that for the Heber/SDGE plant in the areas of the plant EIR and the status of design studies. However, the Imperial County Planning Department is in the process of preparing the EIR for the plant and expects the final document to be completed in 6 to 8 months with approval or disapproval of the application for permit in 10-11 months (from February 8, 1979). They also have applications for 2 CUPs from Chevron for the production/injection well island for the SCE plant and for treatment of the water from New River for cooling and/or reinjection makeup for all future plants at Heber. SCE can provide 100 percent of the required plant-funding. They believe they can meet the scheduled 1982 date, although SDC believes a more realistic date is January 1983 (based on consideration of the time required for permitting). Although SCE considers the flashed steam plant to be a lower risk than the binary (as it makes use of technology already successfully demonstrated at Cerro Prieto), they believe that the main problem area is technical: the possibility of air leakage into the second stage steam separator if the low operating pressure drops below atmospheric and any pin-holes are present.

A detailed schedule and schematic diagram for this plant are not yet available from SCE.

At this time there are no recommendations to be made to DOE as the above problem is considered to be very minor.

Item	Data	Ref/Page
On Line Date	10/82 (SCE), 1/83 (SDC)	64
Location	Heber, Imperial Valley, S. Ca.	
Reservoir/Power Plant Operator	Chevron/SCE	
Cycle	2 stage flash	
Present Status	Preliminary engineering studies completed end of July. Agreement with Chevron for steam was signed prior to 12/15/78	123
Plant EIR Status	Application has been made to Imperial County. Final document expected to be completed in 6-8 months	124
Plant Cost	\$63M	123
Funding	100% SCE	
Power Cost, Mills/KWhr	Steam is competitively priced	123
No. of Wells Drilled	None (existing wells are too far away--excessive ΔP in pipes due to low pres.wells)	
Total required for plant	8-10 production	
Bottom Hole T	360°F	Assuming same as for Heber/SDGE/45 MWe plant.
Salinity, ppm	14000 PPM	
Avg. Flow Rate/Well	585 K lb/hr	
Average Depth	5500 ft.	
Reservoir Potential, MWe	970, 400-500 for 10K' deep wells	1/1-16, 25/11-6
Reservoir Proven (30 yr), MWe	400 to 500 (Chevron)	123
Water Source Status	Reinjection makeup water to be treated water from New River.	39
Transmission Line Status	Existing adjacent IID line to be used.	39
Major Problem Area	2nd stage steam separator due to low pressure.	64

Figure 2-8. Heber/SCE/45 MWe Power Plant General Information Summary (As of 2/8/79)

Name <u>Lee Roberts</u> Phone <u>213-572-2612</u>	Name <u>James Griswold</u> Phone <u>213-572-1888</u>
Organization Unit <u>Southern California Edison</u>	Organization Unit <u>SCE</u>
Title or Position <u>Manager, Field Supply Services</u>	Title or Position _____
Specialty <u>In charge of negotiations with Chevron</u>	Specialty <u>In charge of analysis of geothermal</u>
_____	_____ <u>plant design.</u>
Location <u>Rosemead, CA</u>	Location <u>Rosemead, CA</u>
<u>VISITED 7/19/78</u>	
Name <u>Norm De Haven</u> Phone <u>213-572-1798</u>	Name <u>Bill Cambell</u> Phone <u>415-894-0268</u>
Organization Unit <u>SCE</u>	Organization Unit <u>Chevron Resources</u>
Title or Position <u>Project Manager - Heber</u>	Title or Position _____
<u>Power Plant</u>	Specialty _____
_____	_____
Location <u>Rosemead</u>	Location <u>San Francisco</u>
<u>VISITED 6/13/78, 8/16/78</u>	
Name <u>Ray Cedillo</u> Phone <u>213-572-1505</u>	Name <u>Al Cooper</u> Phone <u>415-894-0268</u>
Organization Unit <u>SDC</u>	Organization Unit <u>Chevron Resources</u>
Title or Position <u>Research Engineering</u>	Title or Position <u>Manager of Geothermal Resources</u>
Specialty _____	Specialty _____
_____	_____
Location <u>Rosemead</u>	Location <u>San Francisco</u>

Figure 2-9. Key Personnel Contacted, Heber/SCE/45 MWe

2.1.3 Salton Sea/SDGE/50 MWe Power Plant & GLEF

Figures 2-10 and 2-11 present the General Information Summary and Key Personnel Contacted for this plant. A decision to proceed with this plant depends on the success of the SDGE tests at the Geothermal Loop Experimental Facility (GLEF) which are scheduled to be completed in 1979 (Figure 2-13).

A General Information Summary is presented for the GLEF in Figure 2-12. It is sized for 10 MWe and has been operating since May 1976, without a turbine, under a 50/50 SDGE/DOE cost sharing program. There are no plans to install a turbine as it is an experimental facility with the purpose of solving the problems of scale buildup and removal or prevention in the plant and wells. (The brine has an average dissolved solids content of 250K ppm, Appendix A.) It was recently converted from a four-stage flashed steam/binary cycle to a dual two-stage flashed steam plant (Figure 2-14) as the steam appears to be clean enough to use in the turbines. (Note that the binary heat exchangers were retained to serve as condensers for the steam.) The GLEF tests to be made and the test schedule are shown in Figure 2-13. The conversion to a dual two stage flash design was completed in early July, 1978.

Cost studies by Bechtel/Holt (Ref. 36) indicate a two stage 50 MWe flash plant would have a lower bus bar cost than a four stage. As shown in Figure 2-10, the levelized cost (Ref. 36/A-13) of the power for the 50 MWe plant is estimated to be 37.6 mills/KW-hr in 1977 dollars*, which is competitive with fossil fuel and nuclear plants.

A Problem Area Summary for the GLEF is shown in Figure 2-15. It can be seen that very good progress is being made in reducing costs due to scaling. The scale cleaning cost for a 50 MWe plant is expected now to be only 0.3 mills/KW-hr. The use of a redundant pair of flash tanks in the 50 MWe plant (three circuits or "trains" when only two are required for operation) has a strong positive effect on capacity factor as it eliminates the necessity for shutting down half of the plant for cleaning the flash tanks.

*Page 4-51 of the 5/78 Bechtel/Holt report states 1988 dollars. However, during the 5 July 1978 visit, SDGE stated that the reference to 1988 dollars was a misprint and that the cost is actually in 1977 dollars.

It is recommended that the DOE continue the 50 percent cost sharing program for the GLEF until maintenance costs due to scaling, and performance and reliability, are demonstrated to be acceptable for a 50 MWe plant.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>	
SCHEDULED ON-LINE DATE	1982 (Holt Report), 3/83 (SDC)	36/2-7	
LOCATION	Salton Sea, Imperial Valley, S. CA		
CYCLE	2-stage flash (3 parallel trains with one redundant) Unmodified brine.	36/4-42	
RESERVOIR/POWERPLANT OPERATOR	Magma Power/SDGE	36/3-2	
PLANT EIR STATUS	Application submitted to Imperial County October 1978	83	
PRESENT STATUS	Feasibility Study report completed by Bechtel/Holt May 10, 1978 (Ref. 36)	36	
PLANT COST	\$38.4M for plant + \$9.8M for well field incl. escalation to 3/82.	36/2-7	
FUNDING	SDGE		
POWER COST, MILLS/KWhr.	37.6 ('77 dollars)	49 (Visit)	
POWERPLANT CAPACITY FACTOR	85% expected eventually	36/4-10, 49	27
NUMBER OF WELLS REQUIRED	16 production + 7 injection initially; double during next 30 years due to reservoir decline.	36/4-17	
Downhole Temp.	500°F initially, 482 after 30 years	36/3-3	
Flow Rate/Well, Avg.	400K lbs./hr. initially, 300K after 30 years	36/3-3	
Dissolved Solids	20%	36/3-3	
Wellhead Pressure	150 psig. constant over 30 years	36/3-3	
Depth, Cost/Well	Production = 400 ft., \$300K	36/3-4	
RESERVOIR POTENTIAL, MWe	2800 (USGS, '75), 2500 (Industry panel, '76), 2000 (JPL, '77)	1/1-17	
Reservoir Proven (30 yr.)	200 MWe (very questionable)	1/1-16	
WATER SOURCE	Reinjection makeup: fresh water from IID for first 5 years, then use of treated irrigation drainage water is planned.	36/3-5	
TRANSMISSION LINE	Connect to existing 92 KV IID line.	36/3-5	
MAJOR PROBLEM AREA	Depends on success of GLEF tests.	49	

Figure 2-10. Salton Sea/SDGE/50 MWe Power Plant General Information Summary (As of 1/11/79)

Name RICHARD SWANSON Phone 714-232-4252

Organization Unit SAN DIEGO GAS & ELECTRIC

Title or Position GEOTHERMAL PROGRAM MANAGER

Specialty PLANNING, FINANCIAL PERMITTING AND

SUPERVISION OF SDGE's GEOTHERMAL PROGRAM

Location SAN DIEGO

Visited 5/17/78 AND 7/5/78

Name BILL JACOBSON Phone 714-232-4252*

Organization Unit SAN DIEGO GAS & ELECTRIC

Title or Position GLEF PROJECT MANAGER

Specialty TECHNICAL

Location SAN DIEGO AND TEST SITE

* X 1750 = SAN DIEGO, X 2061 = SITE

VISITED 5/12/78 AND 7/5/78

Name HARRY BISHOP Phone 714-232-4252

Organization Unit SAN DIEGO GAS & ELECTRIC

Title or Position CHEMICAL SECTION SUPERVISOR

Specialty

Location SAN DIEGO

Name Phone

Organization Unit

Title or Position

Specialty

Location

Name Phone

Organization Unit

Title or Position

Specialty

Location

Name Phone

Organization Unit

Title or Position

Specialty

Location

Figure 2-11. Key Personnel Contacted, Salton Sea/SDGE/50 mWe and GLEF

ITEM	DATA	REF/PAGE
IDENTIFICATION	Geothermal Loop Experimental Facility, sized for 10 MWe, no turbine	
SCHEDULED ON LINE DATE	Loop operating since 5/76. No plans for turbine. Tests scheduled to be completed in 1979. (Figure 2-13)	49 (visit 7/5/78) and 120
CYCLE	4 stages flashed steam/binary initially. Converted to dual 2 stage flash with brine clarifier	
PLANT COST	\$12M, (initial + operating and testing costs)	
FUNDING	SDGE 50%/DOE 50%	
POWER COST, MILLS/KWHR.	Turbine not econom. feasible for GLEF. Estimate 38 mills/KW hr for 50 MWe flash plant.	36/4-31
NO. OF WELLS DRILLED	4 (2 production, 2 injection), Magma Power Co.	14A/249
Additional Required	None for GLEF, 2nd prod. well to be reworked	34
Wellhead T in Tests	380-440°F	21/2
Flow Rate/Well in Tests	400K lbs/hr (1 well only)	21/2, 34
Dissolved Solids	250K ppm	6/11-1
Depth, Average	3500 ft.	34
RESERVOIR POTENTIAL	2800 (USGS, 75), 2500 (Industry Panel, 76)	1/1-17
Reservoir Proven (30 yr.)	200 MWe, (very questionable)	1/1-16, 34
WATER SOURCE STATUS	Now using irrigation supply water for cooling. May be able to use irrig. drainage ditch water or Salton Sea.	49
PLANT AVAILABILITY	Improving; 47%, 9/76 to 9/77; 60% for past 6 mos., including scheduled shutdown after 6 weeks oper.	34
MAJOR PROBLEM AREA	Scaling and injection reliability - large improvements being made - see Problem Area Summary.	49

Figure 2-12. Salton Sea/SDGE/GLEF Information Summary

Test No.	Title	<div style="text-align: center;"> ** ↓ * </div> Year 1978								Year 1979
		May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1	Scaling in Plant (rates measurement)	_____	_____	_____	_____	_____	_____	_____	_____	
2	Plant Scale Removal Methods			_____	_____	_____	_____	_____	_____	
3	Corrosion and Erosion in Plant	_____	_____	_____	_____	_____	_____	_____	_____	
4	Reliability and Longevity of Plant Components	_____	_____	_____	_____	_____	_____	_____	_____	6 Months
5	Performance of Injection Wells	_____	_____	_____	_____	_____	_____	_____	_____	6 Months
6	Precipitation of Solids Prior to Injection	_____	_____	_____	_____	_____	_____*	_____	_____	6 Months
7	Scaling and Corrosion of Injection Wells	_____	_____	_____	_____	_____	_____	_____	_____	
8	Performance of Production Wells	_____	_____	_____	_____	_____	_____	_____	_____	
9	Scaling and Corrosion of Production Wells	_____	_____	_____	_____	_____	_____	_____	_____	
10	Brine Compatibility	_____	_____	_____	_____	_____	_____	_____	_____	
11	Ground Subsidence	_____	_____	_____	_____	_____	_____	_____	_____	
12	Two Phase Flow and Plants Stability	_____	_____	_____	_____	_____	_____	_____	_____	
13	Noncondensable Gases	_____	_____	_____	_____	_____	_____	_____	_____	
14	Reservoir Performance	_____	_____	_____	_____	_____	_____	_____	_____	6 Months
15	Steam Cleaning					_____	_____	_____	_____	

** Complete conversion to dual 2 stage.

* Clarifier installed

REF. 36, Bechtel/Holt Report, 5/10/78, page 8-8.

Figure 2-13. Schedule of Recommended Tests For Geothermal Loop Experimental Facility

GLEF PROCESS FLOW DIAGRAM

Figure 2-14. Salton Sea/SDGE/2 Stage Flash GLEF

Major Problem Area: Scaling throughout plant

1. Injection well plugging due to scaling and suspended solids (SS). Commercially available clarifier tank to be installed in brine injection line - expected to reduce SS from 300 ppm to 50 ppm. Use of a dual media filter in addition is expected to reduce SS to 5 ppm (clean by periodic back-flushing). Clarifier tank sediment to be trucked away periodically. May be able to sell for mineral recover as at Cerro Prieto.
2. Injection line (10", 1 mi. line) was scaling at 1 to 2 inches/1000 hours = average of 377 loss in area per month (21/32). Cost to clean with hydrojet was \$50K (21/16). Daily pigging has resulted in constant scale thickness of 3/8" at a cost of (\$150/pig) (6 pigs/month) = \$900/mo. (ref. 34).
3. Brine system (flash drums and lines) scaling at average of 1 mill/hr = .7"/month (21/8). Cost to clean entire plant with hydrojet after six weeks of operation = \$15K. Expected to be \$13K/year for 50 MWe plant in which case cleaning cost will be only .3 mills/KWhr. (Ref 36/A-12, 4-51). This is based on a comparison of the surface area of the vessels and interconnecting lines which is about the same for the 2 plants, due to the use of 2 stages versus 4 (Ref. 119).
4. Injection pump bearing and seal failures due to scale (21/37). The new location downstream of clarifier and dual media filter (Figure 2-14) should alleviate this problem.
5. Valves - All have jammed due to scaling. Pinch valves show promise.

Recommendation for DOE - Continue 50% cost sharing of the GLEF until maintenance costs due to scaling, and performance and reliability, are demonstrated to be acceptable for a 50 MWe plant.

Figure 2-15. Power Plant Problem Areas Summary, Salton Sea/SDGE/GLEF

2.1.4 Salton Sea/SCE/10 MWe Power Plant

Figures 2-16 and 2-17 present the General Information Summary and Key Personnel contacted for this plant. It should be noted that the lease holders (Union Oil, Mono Power and Southern Pacific Land Co.) signed an agreement on 24 April 1978 to explore the lands near Niland at the southern end of the Salton Sea. Union will drill and test four new wells starting in September 1978 to determine the best techniques to extract, handle and reinject the geothermal fluids (Ref. 60). When these have been determined, SCE will build and operate a 10 MWe plant with a scheduled construction start date of mid-1980 and an on-line date of mid-1982. If successful this would be followed by a 50 or 100 MWe plant. A detailed schedule has not yet been developed, so one cannot be included at this time.

Funding and permitting are not considered to be problem areas at this time. The main problems are considered to be scaling due to the 25 percent dissolved solids, injection well reliability, and well life. Since very good progress is now being made regarding these problems at the SDGE/DOE GLEF (Figure 2-15), the findings will be very valuable to SCE.

ITEM	DATA	REF/PAGE
SCHEDULED ON LINE DATE	Mid '82; start construction mid '80. To be followed by 50 or 100 MW _e plant, if successful.	59; 62 (Visit)
RESERVOIR OPERATOR	Union Oil	60
LEASE HOLDERS	Union Oil, Mono Power (SCE subsid.) and Southern Pacific Land Co. Exploration Agreement signed 4/24/78.	60 } Union Press Re-lease 4/24/78
POWER PLANT OPERATOR	SCE to build and operate plant	60 }
PRESENT STATUS	During a 2 year period Union will drill and test 4 new wells near Niland per 4/78 agreement.	60 }
CYCLE	Flashed steam, 1 stage	62
EIR STATUS	EIR for 10 wells completed 6/30/78; 8 approved 7/12/78. Application for plant EIR to be submitted in mid '79.	61, 57, 62
COST	Wells and test program \$9M, Plant = \$12-15M	111
FUNDING	Union 50%, Mono 25%, SPLC 25% for well program. SCE to fund power plant.	60 62
POWER COST, MILLS/KW HR.	No estimate available. Preliminary engineering not yet started.	62
NUMBER OF WELLS DRILLED	1 as of 1/79, 2nd underway	111
TOTAL REQUIRED FOR PLANT	2 production and 2 injection	62
Well head temp.	380-440°F for Magma well; similar estimated for Union	21/2
Dissolved Solids	250K ppm	
Flow rate/well	400K lbs/hr for Magma well; similar estimated for Union	6/11-1
Depth	3500 ft. for Magma well; similar estimated for Union	14

Figure 2-16. Salton Sea/SCE/Union Oil/10MWe Power Plant
General Information Summary (1 of 2)

ITEM	DATA	REF/PAGE
RESERVOIR POTENTIAL FOR 30 YR. Proven, 30 yr.	2800 (USGS, '75), 2500 (Industry panel, '76) 200 MW _e (very questionable)	1/1-17 1/1-16
WATER SOURCE	IID Irrigation water requested.	73
TRANSMISSION LINE STATUS	Possible approach is to connect to nearby 92 KV IID line.	62
MAIN PROBLEM AREA	Scaling, injection reliability and well life	111
RECOMMENDATION TO DOE.	Continue 50% cost sharing of the GLEF tests as this is resulting in solving of the above problems	62

Figure 2-16. Salton Sea/SCE/Union Oil/10MWe Power Plant
General Information Summary (2 of 2)

Name George Crane Phone 213-572-2775
 Organization Unit Southern CA Edison
 Title or Position Project Engineer of the Salton Sea
Power Plant and Long Valley Direct
 Location Rosemead, CA
 Visited 8/7/78

Name Joel Robinson Phone 213-486-7398
 Organization Unit Union Geothermal Division
 Title or Position Supervisor Environmental and
Regulatory Compliance
 Location Los Angeles, CA

Name R. L. Roberts (Lee) Phone 213-572-2612
 Organization Unit Southern Cal. Edison
 Title or Position Manager of Field Supply Services
 Location Rosemead, CA
 Visited 7/19/78 (Ref. 59)

Name Anthony Chasteen Phone 714-344-7170
 Organization Unit Union Oil
 Title or Position _____
 Specialty _____
 Location Brawley, CA

Name Dr. Carel Otte Phone 213-486-7000
 Organization Unit Union Oil Geothermal Division
 Title or Position President
 Specialty _____
 Location Los Angeles, CA

Name Steve Lipman Phone 707-542-9543
 Organization Unit Union Oil
 Title or Position _____
 Specialty _____
 Location Santa Clara, CA

Figure 2-17. Key Personnel Contacted--Salton Sea/SCE/Union Oil/10MWe

2.1.5 Salton Sea/McCulloch/DWR 55MWe Power Plant

Figures 2-17A and B present the General Information Summary and Key Personnel Contacted for this plant. This plant is to be built in the Frink Springs area, NE of the Salton Sea. An EIR for two wells was approved and a permit was issued by Imperial County, on October 9, 1978. The scheduled on line date of 1984 is very questionable as it is contingent on several factors. Namely, it is not as far advanced as the McCulloch/DWR 55 MWe plant being planned at South Brawley (Figure 2-28A) and McCulloch has not yet drilled any wells at Frink Springs, nor do they intend to do so until drilling of the Brawley well is completed.

The drilling of the exploration wells and construction of the plant are to be funded by DWR. Reservoir development is to be funded by McCulloch and DWR. A decision to proceed with the plant is contingent on the success of the two wells to be drilled at the site.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Scheduled on line date	1984 (Very Questionable*)	104
Location	Frink Springs, NE Salton Sea, Imperial Valley	221
Cycle		
Reservoir/plant operator	Mc Culloch/DWR	} 117
Present status	Mc Culloch signed an agreement with DWR on 11/3/78 to develop this reservoir.	
EIR status	EIR for 2 wells approved. Permit issued 10/13/78 by Imperial County.	83
Plant cost		
Funding	Exploration cost-DWR; Development cost-Mc Culloch and DWR; plant cost, DWR	117
Number of wells drilled	None. Don't expect to start drilling until well at Brawley is finished (Figure 2-28A)	94
Additional required	} No data available yet	
Bottom hole temperature		
Flow rate/well		
Depth		
Dissolved solids		
Reservoir proven (30 yrs.)		
Major problem area	*A decision to proceed is contingent on the success of the 2 wells to be drilled at this site.	117

Name Roland Russell Phone 213-879-5252
 Organization Unit Mc Culloch Geothermal Resources
 Title or Position Vice President
 Specialty _____
 Location Los Angeles
 Visited 9/21/78

Name Ray Chandler Phone 213-879-5252
 Organization Unit Mc Culloch Geothermal Resources
 Title or Position Project Manager
 Specialty Geothermal Activities
 Location Los Angeles
 Telephone Conversation 9/8/78, 11/7/78

Name _____ Phone _____
 Organization Unit _____
 Title or Position _____
 Specialty _____
 Location _____

Name Judy Warburg Phone 916-422-2841
 Organization Unit CA. Dept. of Water Resources
 Title or Position _____
 Specialty _____
 Location Sacramento, CA.

Name Gary Steenhoek Phone 916-445-6687
 Organization Unit Ca. Dept. of Water Resources
 Title or Position Chief of Resources Development
 Specialty Resource Development
 Location P.O. Box 388, Sacramento, CA 95802
 Telecon 11/8/78 (ref. 104)

Name _____ Phone _____
 Organization Unit _____
 Title or Position _____
 Specialty _____
 Location _____

Figure 17B. Key Personnel Contacted, Salton Sea/McCulloch/DWR/55 MWe

2.1.6 East Mesa/Magma Power 11 MWe Power Plant

Figures 2-18 and 2-19 present the General Information Summary and Key Personnel Contacted for this plant as of February 7, 1979. This plant is under construction with a scheduled completion date of March, 1979. It will be the first power plant in the U.S. to use a hot water geothermal reservoir as the primary energy source. Both the well field and the power plant operators are subsidiaries of Magma Power Company. It is a binary cycle as shown in the schematic diagram, Figure 2-20. The plant is too small to be economically competitive but it is being built to obtain the data required for a 50 MWe plant design at East Mesa. Funding and permitting are not considered to be problems at this time. The main problem is technical; namely, downhole pump bearing failures as noted in Figure 2-21. It is very expensive to pull these pumps and the 800 feet of shafting which contains bearings every five feet, replace the bearings, and reinstall in the well. Preliminary estimates for a 50 MWe power plant yield a busbar cost impact of approximately + 3 to 4 mills/kwh based upon an 80% plant capacity factor and a 12% discount rate (Ref. 72).

It is recommended that DOE fund an R&D program to aid in solving this problem as downhole pumps are vital to provide the required flow rate and eliminate flashing in wells at East Mesa and at other liquid dominated reservoirs.

Item	Data	Ref/Page
Scheduled on Line Date	3/ 79 (Now under construction)	122
Location	East Mesa, Imperial Valley, S. Ca.	
Well Field/PowerPlant Operator	Imperial Magma/Magma Electric (Subsidiaries of Magma Power Co.) J. Hilbert Anderson, Inc. York, Pa.	} 30
Plant Designer		
Cycle	Dual binary (Isobutane, Propane), Figure 2-20	15/1,30
Plant EIR Status	Approved, permit issued 1/'78	30
Construction Start Date	Jan. '78	30
Cost	\$10M (\$909/KW), including wells	30
Funding	Private - Magma Power Co.	30
Estimated Power Cost, Mills/KWhr	40-45. To be sold for 25 (objective is to obtain oper. data req'd for 50 MW plant des.)	30
No. of Wells Drilled	8 (5 production, 3 injection)	122
Additional req'd for plant	None	122
Reservoir T (Also Wellhead T)	185-196°C (365-385°F)	15/3,30
Flow Rate/Well, Avg. in Tests	360Klbs/hr. (800 GPM)	30
Salinity	10K ppm (sea water = 35K ppm)	30
Depth Average (Production)	7400 ft.	30
Reservoir Potential, MWe	487	10/3-4
Proven (30 yr.), MWe	100 (estimated by Magma Power, not proven)	1/1-16,30
Water Source Status	Imperial Irrigation District to provide	30
Transmission Line Status	IID to build. SDGE to purchase power and sell to IID.	30
Hardware Status	Nearly all received - being installed	30

Figure 2-18. E. Mesa/Magma Power/11 MW Power Plant General Information Summary (As of 2/7/79)

KEY PERSONNEL CONTACTED
E. MESA/MAGMA POWER/11 MWe

Name <u>TOM HINRICHS</u>	Phone <u>714-743-7008</u>	Name <u>Norm Hodgdon</u>	Phone <u>714-356-4635</u>
Organization Unit <u>Magma Power Co.</u>		Organization Unit <u>Magma Electric Co.</u>	
Title or Position <u>VP Operations</u>		Title or Position <u>Plant Superintendent</u>	
Specialty <u>All -- technical, financial, permitting.</u>		Specialty <u>In charge of plant operations</u>	
Location <u>332 S. Juniper, Escondido, Ca.</u>		Location <u>E. Mesa Power Plant</u>	
Visited 5/11/78 & 6/28/78			
Name <u>Ben Dambly</u>	Phone <u>717-741-0884</u>	Name _____	Phone _____
Organization Unit <u>J. Hilbert Anderson,</u>		Organization Unit _____	
Time <u>Consulting Engineers</u>		Title or Position _____	
Specialty <u>Ch. Eng. for design of Magma Power Plant</u>		Specialty _____	
Location <u>York, Pa.</u>		Location _____	
Visited 5/11/78 and 6/28/78			
Name <u>Phil La Barge</u>	Phone <u>714-356-4635</u>	Name _____	Phone _____
Organization Unit <u>Magma Electric Co.</u>		Organization Unit _____	
Title or Position <u>Construction Mgr.</u>		Title or Position _____	
Specialty _____		Specialty _____	
Location <u>E. Mesa Power Plant</u>		Location _____	

Figure 2-19. Key Personnel Contacted, E. Mesa/MAGMA Power/11 MWe

Figure 2-20. Power Plant Schematic East Mesa/Magma Power/11 MWe

Main Problem Area: Downhole pump bearing failures

- Peerless 1200 GPM shaft driven downhole pumps
- Bronze bearings every 5' along 800' long shaft are failing with MTBF of only 30-45 days.
- Very expensive to pull these pumps and shafting to replace bearings.
- Preliminary estimate = + 3 to 4 mills/kw hr. at the busbar for a 50 MWe plant (80% capacity factor, 12% discount rate).
- Fund an R&D program to solve this problem. Downhole pumps are vital to provide the required flow rate from the East Mesa wells and other liquid-dominated reservoirs.

**Figure 2-21. East Mesa/Magma Power/11 MWe Power Plant
Problem Areas Summary**

2.1.7 East Mesa/RGI/48MWe Power Plant

Figures 2-22 and 2-23 present the General Information Summary and Key Personnel Contacted for this plant. This is the date of the signing of a Letter of Understanding by SDGE with RGI establishing the basis for a future agreement with RGI, whereby RGI would be responsible for geothermal reservoir management, constructing the plant and arranging financing; while SDGE would operate it, provide transmission facilities and sell the power (Ref. 56). The plant EIR was written by Imperial County, USGS and BLM as the site is on federal lands. It was approved by USGS on September 8, 1978 (Ref. 75).

Permits have been received for drilling 15 wells. Eight wells have been drilled (six production and two injection) for the plant under a \$9M DOE loan guarantee covering about half of the total of 30 wells required for the plant. The plant cost is \$53M and RGI hopes to get a bank loan for this and then lease the plant to SDGE.

Though, as a rule, Imperial County would like to have 100% of the withdrawn geothermal fluids reinjected, they will allow 87% reinjection at this non-agricultural desert site on an experimental basis to assess the resulting subsidence, if any. Since approximately 87% of the geothermal fluid used will be available for reinjection, no makeup water is envisioned at present.

A plant schematic and schedule are shown in Figures 2-24 and 2-25, respectively. This project, referred to here is a "48 MWe" power plant, is in fact composed of a 10 MWe and a 54 MWe generating unit whose net output is 48 MWe. (16 MWe comprise the parasitic load needed for auxiliary power and to operate the downhole production pumps.)

The major problem area for this plant is financial as noted in Figure 2-26. Due to the high risk, as perceived by banks, a Loan Guaranty is essential to obtain bank financing for the plant or field development. It is recommended that DOE sponsor reservoir insurance covering the 25 percent equity portion of the plant cost to reduce the risk in the event the reservoir quality degrades excessively. A second problem is the long delay in obtaining DOE approval for each step in the loan guarantee program for drilling the wells at both East Mesa and Westmorland. This has been very expensive and time consuming for RGI. It is recommended that DOE take the lead in streamlining this process.

ITEM	DATA	REF/PAGE
SCHEDULED ON LINE DATE	10 MWe, 4/80; 48MWe, mid '81	114
LOCATION	East Mesa, Imperial Valley, S. CA.	
RESERVOIR/POWERPLANT OPERATOR	RGI/SDGE; Letter of Understanding signed 7/24/78 for RGI to arrange financing and construct plant; SDGE to operate it.	56
CYCLE	2 Stage Flashed Steam, Figure 2-24	37/2-8
PLANT EIR STATUS	Approved by USGS 9/8/78 (10 MW)	75
FINANCIAL STATUS	10 MW Funded by RGI with DOE Loan Guarantee to be funded by private equity with DOE loan guarantee.	38, 56
Cost	\$53M for plant + \$16M for pipe lines (excl. wells)	114
Funding	\$9M DOE Loan Guarantee for half of wells	37/2-3
Power, Cost, Mills/kwhr	Competitive with new coal or oil fired units	114
NO. OF WELLS DRILLED FOR PP	8 (6 Prod., 2 Inj.) Permits rec'd for 15.	114
Total Req'd for Powerplant	30 (19 Production + 9 Injection + 2 Spares) To be completed by 1980.	37, 2-4, 2-8
Reservoir T (Also Wellhead)	320-360°F (335°F Avg.)	37/2-4
Flow Rate	14.4 x 10 ⁶ lbs/hr, total (19 wells). 759k lbs/hr-well, avg.	37/2-4
Salinity, PPM	1600-2200	32
Depth, Avg.	5000-7500 ft.	37/2-4
RESERVOIR POTENTIAL	500 MWe (USGS '75), 400 (ERDA, 77)	1/1-17
Reservoir Proven (30 yr.)	100 MWe	1/1-16
WATER SOURCE STATUS	None required. Subsidence, if any, due to only 87% reinjection to be tested at this desert site.	38, 108
TRANSMISSION LINE STATUS	SDGE to provide transmission facilities and dispose of power. Transmission line for 10MW plant is installed. (34.5 kv)	114

Figure 2-22. East Mesa/RGI 48 MWe Power Plant General Information Summary (As of 1/26/79) (1 of 2)

ITEM	DATA	REF/PAGE
TECHNICAL STATUS	Well tests completed-awaiting evaluation by DOE. Major portion of design for 10MW unit is complete	114
HARDWARE STATUS	Downhole Peerless pumps being tested. 10MWe turbine ordered. Major plant facility components are ready for order.	114
MAIN PROBLEM AREA	Funding of Powerplant see Figure (2-26)	88

Figure 2-22. East Mesa/RGI 48MWe Power Plant
General Information Summary (as of 7/24/78)

Name Dr. J. H. Barkman (Jim) Phone 213-945-3661
Organization Unit Republic Geothermal, Inc.
Title or Position VP Production
Specialty Project Manager of Planned 48 MW
power plant.
Location Santa Fe Springs, Ca.
Visited 6/12/78

Name Mike Walker Phone 213-945-3661
Organization Unit Republic Geothermal, Inc.
Title or Position Mgr. of Facilities
Specialty Design of planned E. Mesa power plant

Location Santa Fe Springs, Ca.

Name Dwight Carey Phone 213-945-3661
Organization Unit Republic Geothermal, Inc.
Title or Position Manager Environmental Affairs
Specialty Environmental and permitting

Location Santa Fe Springs, Ca.
Visited 6/12/78

Name Carl Fisher Phone 714-352-4434 *
Organization Unit Republic Geothermal
Title or Position Production Superintendent
Specialty Operation and Testing of Wells at E. Mesa

Location East Mesa Field
Visited 5/10/78

Name Bruce Hellier, Ken Chan Phone 415-323-8111
Organization Unit USGS
Title or Position Engineer
Specialty Evaluation of RGI well test data for
DOE under loan guar. prog.
Location Menlo Park, Ca.

Name Tom Lawford Phone
Organization Unit Idaho Nat. Eng. Lab.
Title or Position Engineer
Specialty Review of Design of E. Mesa Power Plant

Location Idaho Falls, Idaho

* Mobile Unit Radio Operator - ask for unit 4176

Figure 2-23. Key Personnel Contacted, RGI/East Mesa/48 MWe Power Plant

Figure 2-24. Republic East Mesa Basic Flow Diagram
48 MWe Power Plant

LEGEND
 ◇ MILESTONE
 □ P.O. ISSUED
 △ SCHEDULED DELIVERY
 ■ 10 MW
 ▨ 54 MW

Figure 2-25. Republic East Mesa 48 MWe Geothermal Power Plant Project Schedule

Figure 2-25. Republic East Mesa 48 MWe Geothermal Power Plant Project Schedule

POWERPLANT PROBLEM AREA SUMMARY

Main Problem Area: Funding of 48 MWe Powerplant

- o The \$9M DOE loan guarantee is for filed development - to provide about half of the 30 wells required for a 48 MWe plant.
- o Funding of the plant must be provided by private equity (with DOE Loan Guarantee) as SDGE is unable to fund new projects at the present time.
- o Private financing is difficult due to lack of any loan guaranties for the 25 percent equity portion of the plant cost.
- o A second problem area is the long time required for approval of each step (including original loan and subsequent milestones) in the DOE loan guarantee program.

Recommendations to DOE:

1. Sponsor some form of reservoir insurance to cover the 25 percent equity portion in the event the reservoir quality degrades excessively. RGI could then obtain a bank loan or private equity to fund the plant.
2. Decrease the approval time required for each step in the loan guarantee program.

Figure 2-26. East Mesa/RGI/48 MWe Power Plant Problem Area Summary

2.1.8. Brawley/Union Oil/SCE/10, 50 MWe Power Plants

Figures 2-27 and 2-28 present the General Information Summary and Key Personnel Contacted for these plants.

Southern California Edison has signed a contract with Union Oil for Union to build the 10 MWe plant (Ref. 59). It is scheduled to start operation in early 1980, which is when Union must start using the resource or renegotiate its lease. The downhole temperature of 500°F is as high as for the Salton Sea (Figure 2-10), but the dissolved solids are much less (10% versus 25%). As of March 9, 1979, the Imperial County Planning Department expected the final EIR draft for the plant to be completed in April or May, 1979.

If it is successful, SCE expects that a 50 MWe plant would be operational in 1984. Following that, power would be brought on line in blocks of 100 MWe/year starting in 1986 (Ref. 59) and reaching a total of 460 MWe by 1990 (Ref. 55). This plant will be funded 100 percent by SCE.

The main problem area is the scaling expected in the plant and wells, but it should not be as severe as at the Salton Sea. Even in the latter case, good progress is being made in solving these problems at the SDGE/DOE GLEF (Figure 2-12).

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Scheduled on line date	10 MWe 1980; 50 MWe 1984 (if 10 MWe is successful); then 100 MW/yr to total of 460 by 1988	59, 110
Reservoir/Powerplant operator	Union Oil/SCE	50
Cycle	Flashed Steam	50
Present Status	Powerplant EIR final due out by 5/79 Contract has been signed between SCE and Union for Union to build the 10 MW plant	59,110
Plant Cost	\$8M for 10 MWe plant	66
Funding of power plants	SCE 100%	66
Power Cost, Mills/Kwhr	Not yet available	66
Number of Wells Drilled	7 in '75-'77. Union Cox #1 and Chevron Rutherford #1 Completed in '77	52
Additional required		
Downhole temperature	260°C (500°F)	50
Dissolved solids	100K ppm (10%)	50, 52
Flow rate	Up to 500K lbs/hr	52
Depth	Cox #1 = 9609', Rutherford #1 = 7930'	52
Reservoir Potential, MWe	330 (USGS, '75), 1000 (Industry, '76)	1/1-17
Reservoir proven, MWe	460 per Union/SCE '78 contract	55
Water Source	SCE has allocation from IID for 5 yrs	66
Transmission line status	IID to purchase power and tie into line ½ mi. away	66
Main Problem Area	Technical problems (scaling), permitting delays	66

Figure 2-27. Brawley/Union Oil/SCE/10,50 MWe Power Plant General Information Summary (As of 1/5/79)

Name Tony Chasteen (714) 344-7170 Phone
 Organization Unit Union Oil Geothermal Div.
 Title or Position Area Manager
 Specialty _____
 Location Brawley, Ca.
 Telcon 5/31/78

Name Richard Lindwell (213) 486/6369 Phone
 Organization Unit Union Oil Geothermal Div.
 Title or Position Manager of Planning and Valuation
 Specialty Head of Steering Committee for Brawley
Power Plant Project
 Location Los Angeles
 Visited 8/18/78

Name Lee Roberts (213) 572-1888 Phone
 Organization Unit Southern California Edison
 Title or Position _____
 Specialty Negotiation of Fuel Contracts
 Location Rosemead, Ca.
 Labriola visited 7/19/78

Name Bill Daniels (213) 486-6415 Phone
 Organization Unit Union Oil Geothermal Div.
 Title or Position _____
 Specialty Project Manager of Brawley Power
Plant Project
 Location Los Angeles, Ca.

Name Joel Robinson (213) 486-7395 Phone
 Organization Unit Union Oil Geothermal Div.
 Title or Position Supervisor Environmental and
Regulatory Compliance
 Location Los Angeles
 Telcon 5/31/78

Name Ray Cedillo (213) 572-1505 Phone
 Organization Unit Southern California Edison
 Title or Position Project Director of Brawley
Power Plant
 Location Rosemead, Ca.

Figure 2-28. Key Personnel Contacted.
 Brawley/Union Oil/SCE/10,50 MWe Power Plant

2.1.9 Brawley, McCulloch/DWR/55MWe Power Plant.

Figure 2-28A and B present the General Information Summary and Key Personnel Contacted for this plant.

The plant is scheduled to go on line in 1983 in the South Brawley area of the Imperial Valley. This date is very questionable, however, due to factors discussed below.

McCulloch Geothermal Resources signed an agreement with DWR on November 3, 1978 to develop this reservoir under a DOE Geothermal Loan Guarantee Program. McCulloch will operate the well field and DWR the power plant if a decision is made to proceed. McCulloch will pay for the drilling cost and DWR will fund the power plant. A loan guarantee for \$1.8M (75% of \$2.5M) has been approved for drilling the wells. Approval of a loan guarantee for development of the reservoir is contingent upon the success of the wells. The EIR for the wells has been approved and permits have been issued for two wells. Drilling was started on Mercer #1 on July 11, 1978 and as of September 20, 1978 a depth of 11,021 feet had been reached. The well is being tested and information on it is proprietary.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Scheduled on line date	1983 (Very questionable*)	104
Location	South Brawley, Imperial Valley, Southern California	221
Cycle		
Reservoir/Plant Operator	McCulloch/ DWR	117
Present Status	McCulloch signed an agreement with DWR prior on 11/3/78 to explore and develop this reservoir under a DOE Geothermal Loan Guarantee Program. A loan has been approved for exploration wells - 75% of \$2.5M	117 117
EIR Status	EIR approved for two wells and permits issued.	83
Funding	Drilling Cost - McCulloch; plant - DWR	117
Power cost, mills/KW/hr.		
Number of Wells Drilled	1st one never drilled; 2nd one, Mercer #1, started drilling 7/11/78.	108, 85
Additional required		
Bottom hole temperature	Proprietary	94
Flow rate	Well being tested.	117
Depth	11021 Ft. as of 9/20/78.	85
Major problem area	* A decision to proceed with a powerplant is contingent on success of the exploration wells and reservoir development wells.	117

Figure 2-29A. Brawley/McCulloch/DWR/55 MWe Power Plant General Information Summary (As of 2/2/79)

Name Roland Russell Phone 213-879-5252
 Organization Unit Mc Culloch Geothermal Resources
 Title or Position Vice President
 Specialty _____
 Location Los Angeles
 Visited 9/21/78

Name Ray Chandler Phone 213-879-5252
 Organization Unit Mc Culloch Geothermal Resources
 Title or Position Project Manager
 Specialty Geothermal Activities
 Location Los Angeles
 Telephone Conversation 9/8/78, 11/7/78

Name Gary Steenhoek Phone 916-445-6687
 Organization Unit Dept. of Water Resources
 Title or Position Chief of Resources Development
 Specialty _____
 Location P.O. Box 388, Sacramento, 95802

Name Judy Warburg Phone _____
 Organization Unit Ca. Dept. of Water Resources
 Title or Position Geothermal Energy Specialist
 Specialty _____
 Location Sacramento, Ca.

Name Vito Magliano Phone 415/273-7943
 Organization Unit DOE/SAN
 Title or Position _____
 Specialty Geothermal Loan Guarantee Program
 Location Oakland, Ca.
 Telcon 11/8/78

Name _____ Phone _____
 Organization Unit _____
 Title or Position _____
 Specialty _____
 Location _____

Figure 2-28B. Key Personnel Contacted, Brawley/McCulloch/DWR/55 MWe

2.1.10 Westmorland/RGI/50 MWe Power Plant

Figures 2-29 and 2-30 present the General Information Summary and Key Personnel Contacted for this plant. It is scheduled to go on line in December 1982. RGI, together with MAPCO of Tulsa, Okla. are the reservoir operators. The power plant operator is not yet known but will probably be SDGE since they have signed a letter of understanding with RGI for the 48 MWe plant at East Mesa (Figure 2-22).

RGI drilled 6 wells but all have plugged up. Additional wells of improved design are to be drilled under a Federal Loan Guarantee as for the East Mesa project. The long delays in processing these applications are a major problem at both locations. The Westmorland application was submitted to DOE in San Francisco on September 29, 1977. Due to the many revisions required, ten months elapsed before it was sent to Washington, where it has been for the past five months. An EIR is being prepared by MAPCO for six more that are to be drilled in 1979 and 1980.

The plant design is scheduled to be done during the last six months of 1980. The source of funding for the plant is not yet resolved. As at East Mesa (Figure 2-26), SDGE will not fund it because of the perceived high risk, and it is difficult for the operators to get an unguaranteed bank loan for the plant for the same reason.

The bottom hole temperatures of 423 to 501°F are much higher than at East Mesa (320 to 360°F). The dissolved solids content of 2 to 7% is intermediate between East Mesa (0.2%) and the Salton Sea (25%). The average well flow rate is 480K lbs/hr versus 400K lbs/hr at the Salton Sea. All of these factors result in lower cost for the wells and the low dissolved solids result in lower operating costs, as well. However, the depth of the production wells is 7000 to 8500 ft versus 4000 ft at the Salton Sea which results in higher well costs. The net effect is moot.

The same recommendations apply for this plant as for the East Mesa plant (Figure 2-26).

<u>ITEM</u>	<u>DATE</u>	<u>REF/PAGE</u>
Scheduled on line date	12/82	65 (visit)
Reservoir Operators	RGI + MAPCO (Tulsa, Okla.)	38
Power Plant Operator	Not yet known	
Present Status	\$29M Federal Loan Guarantee application submitted to DOE, SAN 9/29/77 to further the drilling and development. SAN sent to DOE Wash. 8/9/78	65
Cycle	Probably flashed steam	65
EIR Status	EIR approved for 6 RGI wells. EIR being prepared by MAPCO for ~ 6 more. No application yet made for plant EIR	57
Cost of plant and wells	} Not yet known. Plant design to be done 6/80 to 12/80.	65
Power cost, mills/KW hr.		
Funding	Not yet known.	65
Number of wells drilled	6(4 production + 2 injection); 6 more production wells to be drilled in '79 and '80.	65
Total req'd for power plant	14-19 production wells estimated.	65
Bottom hole temp.	216-260°C (423 to 501°F)	114
Depth	Production = 7000 to 8490 ft.; Injection=4500'	58
Flow rate/well	480K lbs/hr. Average.	114
Dissolved solids, ppm	20K to 70K (2 to 7%)	58
Reservoir potential	400 to 2000 for 30 years (prelim. estimate)	65
Water Source Status	IID may provide	65
Transmission Line Status	Under negotiation	
Major Problem Areas	Funding of power plant and long time required for processing loan guarantee appl.	65
Recommendation for DOE	Sponsor reservoir insurance and streamline loan guarantee processing (see fig. 2-26)	

Figure 2-29. Westmorland/RGI/50 MWe Power Plant General Information Summary (As of 1/26/79)

Name Dr. J. L. Smith (Bill) Phone 213-945-3661
Organization Unit Republic Geothermal Inc.
Title or Position VP Exploration
Specialty Project Manager of planned 50 MWe Power
Plant at Westmorland
Location Santa Fe Springs, CA
Visited 8/17/78

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____
Location _____

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____
Location _____

Name Dr. J. H. Barkman Phone 213-945-3661
Organization Unit Republic Geothermal, Inc.
Title or Position VP Production
Specialty Project Manager of Planned 48 MWe Plant
at East Mesa
Location Santa Fe Springs, CA 11823 Slauson
Visited 6/12/78

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____
Location _____

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____
Location _____

Figure 2-30. Westmorland/RGI/50 MWe Power Plant
Key Personnel Contacted

2.1.11 Coso/China Lake NWC/50MWe Power Plant

Figures 2-31 and 2-32 present the General Information Summary and Key Personnel Contacted for this plant. The plant, whose power will be purchased by the Navy, is scheduled to have a minimum of 10 MWe on line by 1981 and up to 110 MWe by 1986. It is to be built at the China Lake Naval Weapons Center (NWC). A request for proposal is scheduled to go out in February 1979 for a contractor to develop the resource and to construct and operate the power plant. The RFP has been written and has been reviewed by the Navy Chief of Civil Engineering in Washington. The NWC has prepared the EIS for the plant and it is now being reviewed.

DOE funded the drilling of a test well to 4800 feet in 1977. The maximum temperature was 385°F (2070 feet). It was recently flow tested and the flow rate was only 20K lbs/hr of dry steam at 120°C (250°F) at a pressure of 16 psig. The low flow rate and pressure were very disappointing, but further tests are planned from November 4 through 11, 1978.

The major problem area is the low flow rate of the well. It has been recommended that efforts be continued to increase the flow rate--including perforating at the high temperature 2070 foot level (above the debris at the bottom of the hole). The use of downhole pumps as at East Mesa (Figures 2-18 and 2-22) should also be considered.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Scheduled On Line Date	Minimum of 10 MWe by '81, maximum of 110 MWe by '86	121
Reservoir/Power Plant Operator	Not yet decided. RFP being prepared for a contractor to develop the resource and construct a power plant on the NWC at contractor expense and operate it with all power to be purchased by the Navy.	63
Present Status	RFP sent to Washington for review in Sept. Due out 2/79. High priority assigned by Navy Chief of Civil Engineering in Washington.	86
Permitting Status	All state permits for drilling wells have been received. NWC has prepared EIS for exploration. It is now being reviewed.	86
No. of Wells Drilled	One, funded by DOE (CGEH #1)	44
Depth	4800 Ft., Drilled in '77 by CER Corp.	44
Downhole Temperature	385°F at 2070', 330°F at bottom Na / K / Ca Thermometry indicates 440°F USGS estimates 450-530°F	63
Salinity	5000 ppm	63
Flow Rate	20K lbs/hr of dry steam at 250°C and 16 psig	86,91
Reservoir Potential (30 Yr)	4500 MWe (USGS, '75), 2000 (ERDA, '77)	1/1-17
Proven (30 Yr)	0	11, 1/1-5
Water Source	Rose Valley wells 12 miles away for drilling geothermal wells. 100% reinjection will probably not be necessary due to fractured granite formation which is not likely to subside.	63

Figure 2-31. Coso/China Lake Naval Weapons Center/50 MWe Power Plant General Information Summary (As of 1/12/79) (1 of 2)

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Transmission Line Status	SCE and LA Municiple transmission lines within 8 miles of well.	10/2-12
Other Activities at Coso	BLM has contracted with Rockwell International to prepare ES for leasing non-Navy land and withdrawn Navy lands. Leasing is expected to start in December 1980. City of Burbank is investigating a 750 MWe hybrid (coal/geothermal) electric plant at Coso.	121 69
Major Problem Area	Low flow rate of well (20K lbs/hr).	86
Recommendation to DOE	Continue funding of exploration program. Try to increase the natural flow rate and, if unsuccessful, consider the use of downhole pumps or drilling another well in a more promising location.	

Figure 2-31. Coso/China Lake Naval Weapons Center/50 MWe Power Plant General Information Summary
(As of 1/12/79) (2 of 2)

Name Martin Pearson Phone 415-877-7506
Organization Unit Naval Facilities Eng. Command
Title or Position Geothermal Project Mgr.
Specialty _____

Location San Bruno, CA.

Name John Howard Phone 415-843-2740
Organization Unit LBL
Title or Position Well Test Coordinator
Specialty _____

Location Berkeley, CA

Name Mark Longley-Cook Phone 415-871-6600
Organization Unit Naval Facilities Eng. Command
Title or Position Utilities Engineering
Specialty Preparation of RFP for power plant at
China Lake NWC.
Location San Bruno, CA.

Name Dr. Carl Austin Phone 714-939-2700
Organization Unit _____
Title or Position Naval Weapons Center
Specialty Geothermal Proj. Officer

Location China Lake, CA.
Visited 8/9/78

Name Dr. J. A. Whelan (Jim) Phone 714-939-2700
Organization Unit Naval Weapons Center
Title or Position _____
Specialty Performance of Coso Well
CGEH #1 (4800')

Location China Lake, CA.
Visited 8/9/78

Name Bob Clark Phone 702-734-3251
Organization Unit DOE
Title or Position Proj. Eng. Coso DOE well.
Specialty _____

Location Las Vegas, Nev.

Figure 2-32. Key Personnel Contacted, Coso/China Lake Naval Weapons Center/50 MWe

2.1.12 Mono-Long Valley/SCE/60MWt Direct Heating Plant.

Figures 2-33 and 2-34 present the General Information Summary and Key Personnel Contacted for this plant. The plant would heat the buildings and swimming pools in Mammoth Lakes Village by means of hot water flowing through heat exchangers. (They are now being heated by electricity and LPG, respectively.) The plant is scheduled for completion in 1982 or 1983 if a decision to proceed is made by SCE. SCE is evaluating the DOE funded Ben Holt feasibility study and is also evaluating an SCE funded Ben Holt study of a co-generation plant (parallel 60 MWt heating and 32 MWe electric plant)* which is briefly discussed on page 78 of reference 40.

The cost of \$15.2M for the heating plant may be funded by SCE. However, they expect to explore cost sharing with DOE or through a special heating district set up by the County or the residents.

The heating cost is estimated by Ben Holt to be 22 mills/KWt-hr for a nonprofit public owned system and 32 mills/KWt-hr for an investor owned system, compared to a cost of 34 to 42 mills/KWe-hr for electricity now used to heat the buildings.

A total of 8 wells has been drilled by Magma Power Co. of Los Angeles. The temperature averages 340°F and the flow rate averages 400K lbs/hr.

The major problem area is that SCE is dubious about the economics of the heating plant due to the 20% capacity factor. (It would only operate 20% of the year and would be idle during the remainder of the time). If a co-generation plant is built, the economics would be improved as the electric plant and the wells required for it would operate throughout the year. However, the residents in the area oppose a power plant due to the vapor plumes that would emanate from cooling towers.

*MWt denotes thermal megawatts while MWe refers to electrical power in megawatts.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Location	Casa Diablo (Wells), Mammoth Lakes Village (Plant)	111
Scheduled On Line Date	1982 or 1983	87/2
Reservoir Operator	Magma at present. Operator for plant wells not yet selected	62
Present Status	DOE funded feasibility study by Ben Holt completed for heating the buildings and swimming pools in Mammoth Lakes Village. SCE and others are evaluating results including the feasibility of a co-generation electric plant (Ref. 40/78)	88
Plant EIR Status	EIR not yet applied for.	62
Cost	\$15.2M for wells, pumps, heating plant and lines.	87/9
Funding	SCE and/or Special Heating District.	62
Heating Cost	22-32 mills/Kwt-hr vs. 34 to 42 Mills/KWe-hr for electricity now used to heat the buildings	87/2, 40/71
No. of Wells Drilled	8 by Magma Power Co.; 7 tested in '60 and '62, 1 in '74, 1 in '78.	40/37, 39
Total Required for Plant	7 (3 new production wells + 2 existing + 2 new injection)	40/65
Wellhead Temperature	340°F for 5 wells (300-360°F)	40/40
Average Flow Rate/Well	460K lbs/hr for 5 wells; (300-700K lbs/hr range)	40/40
Depth	644' average for 5 wells (405-810')	40/37
Salinity	1000-1500 ppm (<0.2%)	42
Reservoir Potential (30 Yr)	6100 MWe (USGS, '75), 2000 (ERDA '77)	1/1-17
Reservoir Proven (30 Yr)	50 MWe	1/1-16

96

Figure 2-33. Mono-Long Valley/SCE/60 Mwt Direct Heating Plant General Information Summary (As of 1/8/79) (1 of 2)

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Major Problem Area	SCE is dubious about economics of the heating plant due to 20% capacity factor (it would only be operating 20% of year). The people are against a power plant due to steam plumes from cooling towers.	88
Other Activities in Area	California Energy Commission has been funding Ben Holt Demo project for heating a lumber store. Six weeks of operation as of 11/2/78. Have Peerless pump scaling problems. Tests to continue to April 1979 under DOE funding. An EAR is being prepared by USFS for land leasing; expect completion 1 November 1978.	89, 90 68
Recommendations to DOE	None unless SCE decides not to fund the plant.	

Figure 2-33. Mono-Long Valley/SCE/60 Mwt Direct Heating Plant General Information Summary
(As of 1/8/79) (2 of 2)

Name <u>Anker Sims</u> Phone <u>795-6866</u>	Name <u>Syd Willard</u> Phone <u>(916) 920-6031</u>
Organization Unit <u>Ben Holt Co.</u>	Organization Unit <u>CA. Energy Commission</u>
Title or Position _____	Title or Position <u>Geothermal Program Specialist</u>
Specialty <u>Author of Ref. 40-Feasibility of</u>	Specialty <u>Project Coordinator for Mammoth demo</u>
<u>Geothermal Heating of Mammoth Lakes Village</u>	<u>heating project (Ref. 89)</u>
Location <u>Pasadena</u>	Location <u>Sacramento</u>
	Telecon <u>11/2/78</u>
Name _____ Phone <u>(213) 572-2775</u>	Name <u>Hillary Sullivan</u> Phone _____
Organization Unit <u>SCE</u>	Organization Unit <u>DOE</u>
Title or Position <u>Project Engineer on Long Valley</u>	Title or Position <u>Project Manager of Feasibility</u>
<u>32 MWe Co-generation plant.</u>	<u>Study by Ben Holt for heating Mammoth</u>
	<u>Lakes Village</u>
Location <u>Rosemead, Ca.</u>	Location <u>San Francisco, Ca.</u>
Visited <u>8/7/78 and 11/1/78</u>	
Name _____ Phone _____	Name <u>Greg Simat</u> Phone <u>213/847-8600</u>
Organization Unit _____	Organization Unit <u>City of Burbank</u>
Title or Position _____	Title or Position _____
	Specialty <u>Investigation of hybrid (coal/geoth.)</u>
	<u>elec. plant at Long Val. and other KGRA's.</u>
Location _____	Location <u>Burbank, Ca.</u>
	* Not cost effective at Long Valley (ref 69).

Figure 2-34. Key Personnel Contacted, Mono-Long Valley/SCE/60 MWt

The California Energy Commission has been funding a Ben Holt demonstration project for heating a lumber store in Mammoth Lakes Village. It had operated a total of 6 weeks as of November 2, 1978. The flow rate and pressure have been decreasing possibly due to scaling of the Peerless downhole pump. The pump has been sent to Peerless for cleaning and modification of the lubrication system. Tests are to be continued to April 1979 under DOE funding.

2.1.13 Geysers-Hot Water

Figures 2-35 and 2-36 present the General Information Summary and Key Personnel Contacted. At the present time there are no plans for any power plants.

Only three applications for geothermal wells have been received by Lake County for the hot water area. The projects to date are Phillips/Borax, Union Oil in the Thurston Creek area, and Magma/Watson. Each has drilled one well. The Magma well was not successful and was abandoned. The Phillips/Borax project has applied to the county for permits to redrill on their leasehold.

PG&E plans to preferentially develop the steam field prior to any development in the hot water area. (The relatively high cost of hot water plants and the potential problems of fluid disposal in a sensitive area are PG&E's main concerns.) They will monitor the development of hot water technology by some other utility prior to committing themselves. Moreover, PG&E will also wait for a developer with a full field development plan prior to considering any hot water projects at the Geysers.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
On Line Date	No power plants planned by PG&E or anyone else at this time.	226
Location	Geysers, Lake County, near Clear Lake	
Reservoir Operators	Well drilling applications have been received by Lake County from the following: Phillips/Borax, Union Oil (in the Thurston Creek area), and Magma/Watson. Phillips/Borax has applied for a permit to redrill.	106
No. of Wells Drilled	1 by Phillips Petroleum, NE of Clear Lake	106
	1 by Union Oil, W of Clear Lake	106
	1 by Magma, abandoned	106
Temperature	} Proprietary	
Flow Rate		
Salinity		
Major Problem Area	There is a general disinterest in developing this comparatively low quality (and uncertain) resource as long as Geysers Steam remains an attractive prospect. The relatively high cost of hot water plants and the potential problems of fluid disposal in a sensitive area are significant concerns to PG&E.	226

Figure 2-35. Geysers Hot Water General Information Summary (as of 1/22/79)

NAME CARL WEINBERG PHONE 415-781-4211
Organization Unit Pacific Gas and Electric
Title or Position Supervising Civil Engineer
Specialty Geothermal Research & Development

Location San Francisco, CA
Visited 10/25/78

NAME Charles Lee PHONE 801-364-2083
Organization Unit Phillips Petroleum
Title or Position _____
Specialty _____

Location Salt Lake City, Utah
Visited _____

NAME Vare Suter PHONE 707-542-9543
Organization Unit Union Oil
Title or Position _____
Specialty _____

Location Santa Rosa, Ca.
Visited _____

NAME Beverly Westphall PHONE 707-263-2221
Organization Unit Lake County Planning Dept.
Title or Position Acting Planning Director
Specialty _____

Location Lakeport, Ca.
Visited _____

NAME Dot Wilcox PHONE 707-263-2221
Organization Unit Lake County Planning Dept.
Title or Position Planning Commission Clerk
Specialty _____

Location Lakeport, Ca.
Telcon, 11/9/78 (ref. 106)

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

Figure 2-36. Key Personnel Contacted Geysers/Hot Water

2.1.14 Geysers-Steam/Union/PGE/1158 MWe Power Plant (17-Unit total)

Figures 2-37 and 2-38 present the General Information Summary and Key Personnel Contacted for this plant. Units 1 through 12 (totaling 608 MWe) are already on line. (The turbine inlet conditions are dry steam at 338°F and 100 psig.) An additional 550 MWe are scheduled to come on line from March 1979 through June 1984.

The entire funding of \$330M for the new plant units will be provided by PG&E. The power cost of 26 mills/KW-hr is lower than any other form of power except hydroelectric.

The major problem areas are the requirements for (1) H₂S abatement equipment to reduce to acceptable levels the H₂S vented to the atmosphere along with the other noncondensable gases in the steam and (2) new transmission lines for units 18-21 as there is substantial public opposition to building additional transmission lines. These problem areas and recommendations regarding them are summarized in Figure 2-38A.

Figures 2-38 to 2-44 present the General Information Summaries and Key Personnel Contacted for the other Geysers-Steam power plants scheduled to come on line from 1978 to 1984. They are very similar to the above plant and the workbook sheets for them are self explanatory. All have the same two major problem areas as listed in Figure 2-38A.

The operation of The Geysers power plants is challenging because of several factors, including the isolated location, rugged mountain terrain, and environment and operating requirements unique to geothermal plants.

All units are designed for automatic operation. A computer-based information and control center is located at Units 5 and 6. It is manned full-time. Information and alarms from each unit in the system are sent to this center for action by the operator.

The units function as base-load units since abrupt changes in well flow rates cause damage to both the wells and the turbines owing to gross carry-over of water, dust, and debris. When a unit trips off the line, the wells connected to it are allowed to vent to the atmosphere through silencers. These wells are not closed in unless it is determined that the unit must remain off-line for an extended period for maintenance or repairs.

The ambient temperature fluctuates during the year from about 20 to 115°F necessitating forced ventilation of the electrical equipment during the summer and special precautions to prevent freezing of outside equipment, particularly the cooling towers, in the winter. Automobile access to the plant during the winter is difficult owing to narrow, mountain roads that are often ice-covered.

Availability factors for the PG&E units are comparable to, but slightly lower than, that for the PG&E fossil fueled plants. The higher forced outage rate for the geothermal plants is a result of the unexpected failure of auxiliaries and components that usually function without trouble in conventional plants. These components include turbine blades and shrouds, rotating electrical apparatus (exciters and motors), small pumps, and cooling tower fan blades.

Geothermal units at The Geysers are dismantled, cleaned and repaired every two to three years compared with five to eight years for conventional units. Down-time is less, i.e., three to four weeks compared to eight to twelve weeks, because of the smaller size and relative simplicity of the geothermal units.

(Matthew, P., 1975, "Geothermal Operating Experience, Geysers Power Plant," Proc. Second U.N. Symp. on Dev. and Use of Geot. Resources, Vol. 3, San Francisco, CA, May 22-29, U.S. Gov. Printing Office, Washington, DC, 1976.)

ITEM	DATA	REF/PAGE
Location	Geysers, Sonoma County	
Scheduled on line date	Units 1-12 (608 MW): now on line Units 14, 17, 18, 20, and 21 (110MW): on line 6/79, 6/82, 8/83, 6/84 and 6/84, respectively	116
Reservoir/Plant Operator	Union Oil, Thermal Power, Magma/PG&E	202,203
Cycle	Dry Steam	201
Present status	608MW on line; units 13 and 14 under construction.	
Plant EIR status	Completed and CPMC issued for plants 12 and 14. EIRs for units 17-21 will be handled with CEC certification process.	206
Plant cost	\$500/KW (1978 dollars) = \$130M for units 12-21	209
Funding	Field-reservoir operators; Power plant - PGE	202,203
Power cost, mills/KWhr	Steam cost = 16.02, plant cost = 10 (1978)	206
Number of wells drilled	Total of 15 for units 12 and 14 nearly completed.	204
Additional required	15 each for 17, 18, 20 and 21	226
Bottom hole/Wellhead T	475 to 500°F/338°F (100 psig sat. steam at turbine inlet)	206
Flow rate/well	135K lbs/hr., average	206
Salinity	Not applicable for dry steam	
Depth, average	4000-8000 ft.	206
Reservoir potential, MWe	1600 (USGS, '75), 2000 (ERDA, '77)	1/1-17
Proven (30 Yr.) MWe	1238 (Union, Thermal, Magma leases only); covers through #18	201,203
Water Source Status	None required, cooling water = condensed steam	
Transmission Line Status	Existing lines sufficient for units 12, 14 and 17 New lines will be built for units 18-21.	204
Major Problem Area	Air quality and new transmission lines are principle issues (see figure 2-38A)	204

Figure 2-37. Geysers-Steam/Union/PGE/1158 MWe (17-Plant Total) Power Plant General Information Summary (As of 3/9/79)

Ext. 1061
 Name Carl Weinberg Phone (415) 781-4211
 Organization Unit Pacific Gas & Electric
 Title or Position Supervising Civil Engineer
 Specialty Geothermal Research and Development
 Location San Francisco, CA
 Visited 8/16/78, 10/25/78

Name Warren Smith Phone (707) 542-9543
 Organization Unit Union Oil Company
 Title or Position Environmental Engineer
 Specialty Permitting of geothermal projects
 Location Santa Rosa, 2099 Range Ave.
 Visited 8-31-78

Name _____ Phone _____
 Organization Unit _____
 Title or Position _____
 Specialty _____
 Location _____

Name H. Howe Phone 415-781-4211
 Organization Unit PG & E
 Title or Position Supervising Civil Engineer
 Specialty Geothermal Resources Planning and Permitting
 Location San Francisco, Ca.

Telephone Conversation: 9/5/78

Name _____ Phone _____
 Organization Unit _____
 Title or Position _____
 Specialty _____
 Location _____

Name _____ Phone _____
 Organization Unit _____
 Title or Position _____
 Specialty _____
 Location _____

Figure 2-38. Key Personnel Contacted, Geysers/Union/PGE/1162 MWe

MAJOR PROBLEM AREAS

I. Air Quality Requirement

- o California air quality standard for H_2S is 30 ppb.
- o Venting of wells produces H_2S emissions.

Recommendations

1. Continue to fund tests of the EIC $CuSO_4$ scrubbing process.
2. Continue to encourage investigation by PG&E of effectiveness of using iron oxide, NaOH and H_2O_2 to remove H_2S from the condensate.
3. Demonstrate feasibility of H_2O_2 and NaOH injection into upstream steam flow to reduce H_2S emission during venting.

II. Public Opposition to the Required New Transmission Lines FOR UNITS 16 and 18-21.

- o PG&E has designated a series of alternative transmission corridors out of producing areas.

Recommendations

1. Expedite a decision on alternative corridors by Energy Commission.
2. Increase capacity of existing lines.
3. Workshops designed to hear and address legitimate public concerns.

Figure 2-38A. Geysers-Steam Summary of Problem Areas

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Location	Geysers, Sonoma County	
Scheduled on line date	Unit 13, 135MW, 10/79; 16, 110MW, 8/82; 19, 110MW 9/83.	201
Reservoir/Plant Operator	Aminoil/Pacific Gas & Electric	202,206
Cycle	Dry Steam	202
Present Status	Unit 13 under contruction; 16 and 19 proposed.	202
Plant EIR Status	Approved for unit 13, CPUC issued.	202
Plant Cost	\$300/KW=\$106M (1975 dollars)	209
Funding	Field-Aminoil, Plant-PGE	202
Power cost, mills/KWhr	Steam Cost=16.02 (1978); plant cost=10 (1978)	202
Number of Wells Drilled	17 for unit 13, 2 for 16, 0 for 19.	Total of 15 required per 100 MWe 202
Additional req'd	3 for unit 13, 15 for 16, 17 for 19.	
Bottom hole/wellhead T	475 to 500°F/338°F (100 psig sat. steam at turb. inlet)	206
Flow rate/well	135K lbs/hr., average	202
Salinity	Not applicable for dry steam well	202
Depth, average	4000 to 8000 ft.	202
Reservoir Potential		
Proven (30 yr.) MW _e	295; 440 reasonably assured for above leases only.	203
Water Source Status	None required; cooling water=condensed steam	203
Transmission Line Status	Existing lines sufficient for unit 13. New lines required for 16 and 19.	204
Major Problems Area	Air quality and new transmission lines are principle issues. (See figure 2-38A).	

Figure 2-39. Geysers-Steam/Aminoil/PGE/355 MWe (3 unit total) Power Plant General Information Summary (As of 1/22/79)

Name C. B. Jenkins Phone (707) 527-5332
Organization Unit Aminoil USA, Inc.
Title or Position Manager, Geothermal Resources Div.
Specialty Geothermal Energy

Location Santa Rosa, 1150A Coddington Center
Visited 8/31/78

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____

Name Carl Weinberg Phone (415) 781-4211
Organization Unit Pacific Gas and Electric
Title or Position Supervising Civil Engineer
Specialty Geothermal Research and Development

Location San Francisco, Ca.
Visited 8/16/78, 10/25/78

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____

Figure 2-40. Key Personnel Contacted, Geysers/Aminoil/PGE/355 MWe

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Location	Geysers, Sonoma County	
Scheduled On Line Date	01/79 (This is PGE Unit 15)	226
Reservoir/Plant Operator	Thermogenics/Pacific Gas and Electric	202
Cycle	Dry Steam	202
Present Status	Under Construction	202
Plant EIR Status	Approved. Permit issued	202
Plant Cost	\$500/KW (1978 Dollar) = \$330M for units 12-21	209
Funding	PGE	202
Power Cost, Mills/KW Hr.		
No. of Wells Drilled	7 or 8 (total req'd for 55 MWe)	
Additional Req'd for Plant	0	
Turbine Inlet Temp.	338 ⁰ F (Sat. Temp. At 100 Psig.)	206
Flow Rate/Well	135 K Lbs/Hr. Average	206
Depth, Average	8000-10000 Ft.	202
Reservoir Proven (30 Yr.)	Reservoir Proven Through Unit 17 (1128 MWe)	
Water Source Status	None Required	
Transmission Line Status	Existing Line To Be Used	204

Figure 2-40A. Geysers/Thermogenics/PGE/55 MWe Power Plant General Information Summary (As of 1/22/79)

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

NAME Carl Weinberg PHONE (415) 781-4211
Organization Unit Pacific Gas and Electric
Title or Position Supervising Civil Engineer
Specialty Geothermal Research and Development

Location San Francisco, Ca.
Visited 8/16/78; 10/25/78

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

Figure 2-40B. Key Personnel Contacted, Geysers/Thermogenics/PGE/55 MWe

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Location	Geysers, Sonoma County	127
Scheduled on line date	Unit 1-11,81; Unit 2-5,82 (both 55MWe)	214
Reservoir/Plant Operator	Shell Oil/Northern Ca. Power Agency	210
Cycle	Dry steam	
Present status	NOI submitted to CEC, 8/78 for both units. Construction to start 8/79	210
Plant EIR status	EIR will be prepared as part of CEC application for certification process.	211
Plant cost	\$56M (1982 dollars), \$500/KW	211
Funding	27% NCPA, 73% DOE guaranteed loan. Qualified for loan guarantee as of 8/78.	210V2/1-7
Power cost, mills/KW hr.	28.8 in 1982 dollars	210
Number of wells drilled	5; exploration is completed	210
Additional required	15; all leases acquired.	210
Turbine inlet Temp.	337°F (sat. steam at 113 psia turbine inlet pres.)	210
Flow rate/well, average	90K lbs./hr.	210
Depth	4500 to 10,000 ft.	
Reservoir proven (30 yr.)	28 MWe based on the 5 wells drilled to date	210
Water Source Status	None required-cooling water=condensed steam.	
Transmission Line Status	Wheeling agreement being negotiated with PGE	210,211
Major Problem Area	Air quality and transmission lines are issues. Stretford H ₂ S abatement process will be used.	

Figure 2-41. Geysers-Steam/Shell/NCPA/110 MWe (2 units total) Power Plant General Information Summary (As of 2/9/79)

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Location	South Geysers, Sonoma County	117
Scheduled On Line Date	October, 1983	214
Reservoir/Plant Operator	Geothermal Kinetics, Inc./Dept. of Water Resources.	}
Cycle	Dry Steam	
Present Status	Plant being designed by DWR	
Plant EIR Status	Start date not yet available	
Plant Cost	\$300-600/KW (\$16-33M), estimated.	}
Funding	GKI--Wells; DWR--Plant	
Power Cost, Mills/KW Hr.	Not yet known	
No. of Wells Drilled	1 by GKI; 2 more to be drilled soon.	
Additiona Req'd per Plant	5 (total of 8 production wells required)	
Turbine Inlet Temperature		
Flow Rate/Well, Average	135K lbs/hr	225
Depth	7000-9000 feet	
Reservoir Proven (30 Yr)	2000 MWe (Industry Panel '76, for Geysers)	2/1-17
Water Source Status	None required; cooling water = condensed steam.	
Transmission Line Status	Will tap into existing transmission line	117
Major Problem Areas	None. H ₂ S abatement is not considered to be a problem as they will use whatever equipment is found to be satisfactory by PG&E	

Figure 2-42A. Geysers/GKI/DWR/55 MWe Power Plant General Information Summary (As of 2/2/79)

NAME ED TERHAAR PHONE 916-445-6687
Organization Unit CA Dept. Water Resources
Title or Position _____
Specialty Resource Development

Location Sacramento, CA
Visited 8/17/78

NAME GARY STEENHOEK PHONE 916-445-6687
Organization Unit CA Dept. Water Resources
Title or Position Cheif of Resources Development
Specialty Resource Development

Location Sacramento, CA
Visited 8/17/78

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

Figure 2-42B. Key Personnel Contacted, Geysers/GKI/DWR/55 MWe

Name P. Michaels Phone 408-248-3422
Organization Unit Northern CA Power Agency
Title or Position General Manager
Specialty _____
Location Santa Clara, 770 Kiely Blvd.

Name N. Ingraham Phone 408-248-3422
Organization Unit Northern CA Power Agency
Title or Position Manager-Geothermal Project
Specialty _____
Location Santa Clara, CA
Visited 9/1/78, 9/26/78

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____
Location _____

Name L. Marquis Phone 408-248-3422
Organization Unit Northern CA Power Agency
Title or Position Manager - Engineering
Specialty _____
Location Santa Clara, 770 Kiely Blvd.

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____
Location _____

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____
Location _____

Figure 2-42 Key Personnel Contacted, Geysers Site, NCPA-110MWe

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Location	Bottle Rock, Lake County	213
Scheduled on line date	4/83	214
Reservoir/Plant Operator	Mc Culloch, GKI, Entex/Ca. Dept. Water Resources	
Cycle	Dry Steam	213, 216
Present status	NOI submitted to CEC on 10/5/78. Construction expected to start in mid 80.	117
Plant EIR status	EIRs to be prepared by Lake County and Energy Commission. (expected to start 1/79).	117
Plant cost	Estimated \$300-600/KW (\$16.5-33M)	
Funding	Field - operators; Plant - DWR	
Power cost, mills/KW hr	Not yet known	
No. of wells drilled	2 (1 shut in - must be redrilled)	213
Additional required	6 (Full field EIR for 12 prod. + 3 inj. wells will be submitted)	216
Bottom hole Temperature	475 to 500°F	213
Flow rate/well	135K lbs/hr. average	213
Depth	7000-9000 ft.	213
Reservoir proven (30 yr.)	Not yet proven	213
Water source status	None required - use steam condensate.	213
Transmission line status	Will tap into existing transmission line	117
Major Problem Area	None. H ₂ S abatement is not considered to be a problem as they will use whatever equipment is found to be satisfactory by PG&E	117

Figure 2-43. Geysers/McCulloch/DWR/55 MWe Power Plant General Information Summary (As of 2/2/79)

Name Roland Russel Phone 213-879-5252
Organization Unit Mc Culloch Geothermal
Title or Position Vice President
Specialty _____

Location Los Angeles
Visited: 9/21/78

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____

Name Ed Terhaar Phone 916-445-6687
Organization Unit Ca. Dept. Water Resources
Title or Position _____
Specialty Resource Development

Location Sacramento, CA
Visited: 8/17/78

Name Gary Steenhoek Phone 916-445-6687
Organization Unit Ca. Dept. Water Resources
Title or Position Chief of Resources Development
Specialty Resource Development

Location Sacramento, CA
Visited: 8/17/78

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____

Figure 2-44. Key Personnel Contacted, Geysers/McCulloch/DWR/55 MWe

2.1.15 Wendel-Amedee/Geoproducts/55MWe Power Plant

Figures 2-45 and 2-46 present the General Information Summary and Key Personnel Contacted for this plant. This plant is scheduled to go on line in 1983.

Both the reservoir and power plant are to be operated by Geoproducts Corp. (GPC) with the California Department of Water Resources (DWR) purchasing the power. It is to be a cogeneration plant that will use geothermal steam to dry wood waste which increases the wood's heating value from 4000 to 8000 BTU/lb. The steam will then be passed through a heat exchanger to heat the boiler feedwater to a wood waste fired boiler which generates the steam for the turbogenerators. The geothermal steam will then be passed through a second heat exchanger to heat greenhouses after which it will be condensed and reinjected.

The plant is to be funded 50% by DWR, GPR and USFS. As a prerequisite to plant construction, DOE and others will be invited to cost share the balance when current negotiations for the first 50% of the funding have been completed.

Gulf Oil Co. drilled a 5000' well at Wendel-Amedee which is on the south side of the fault and has a bottom hole temperature of 248°F. Two shallow 300' to 600' wells have been drilled by GPC which are now in use for heating 30 greenhouses with 205°F water. Permits have been received to drill five 1500' temperature gradient wells and application for a 5000' well is to be made in early 1979. They are all to be located on the north side of the fault where the temperature is expected to be 330 to 430°F. The drilling of these wells is expected to start in the first quarter of 1979.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Schedule On Line Date	1983	214
Location	Lassen County, 20 mi. east of Susanville, NE CA.	71/1
Reservoir/Power Plant Operator	GPC/GPC	71/1
Utility	CA. Dept. of Water Resources to purchase power	71/1
Cycle	Cogeneration (Geothermal steam dries wood waste and then goes into HE to preheat feedwater to wood waste fired boiler and then to warm greenhouse).	71/2
Present Status	Now in Phase 1--Evaluate reservoir + cost of wood waste; prepare ERs. Future Phase 2--Design, construct, operate plant.	71/2
EIR Status for Wells	Permits received for 5 1500' wells. Apply for 5K' in early 79.	113
Cost, Wells + Plant	\$45M	71/1, 77
Funding	Negotiations nearly completed for 50% by DWR, GPR and USFS. Final application will then be made for 50% by DOE and others (expected end of Jan)	110
Power Cost, Mills/KW Hr.	Expected to be competitive with alternate sources.	71/3
Number of Wells Drilled	5000' well by Gulf + two shallow (300' and 600') wells by GPC.	110
Additional Required For Plant)	Expect to start drilling five 1500' wells and one 5000' well in 1st quarter of 1979.	110
Bottom hole Temperature	248°F for Gulf well. Plant is designed for 250°F. Estimate 330°F to 430°F for GPC 5000' well.	110,113
Flow Rate/Well	1500 GPM required; 2000 GPM (1M lbs/hr), expected	76,113
Total Dissolved Solids	1800 ppm (Gulf well)	110

Figure 2-45. Wendel-Amedee/Geoproducts Corp./55 MWe Power Plant General Information Summary (As of 1/16/79) (1 of 2)

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Reservoir Potential (30 Yr.)		
Reservoir Proven (30 Yr.)		
Water Source Status	Adequate water available for cooling pond from large underground aquifer at 300 ft.	110
Transmission Line Status	Existing 50 MW line crosses property.	110
Major Problem Area	Insufficient funds to proceed without cost sharing by DOE.	
Recommendation	DOE cost sharing is recommended as this project appears to be very promising	

Figure 2-45. Wendel-Amedee/Geoproducts Corp./55 MWe Power Plant General Information Summary (As of 11/14/78) (2 of 2)

NAME KEN BOREN PHONE 415-893-8365
Organization Unit Geoproducs Corp.
Title or Position President
Specialty Geothermal Power

Location Oakland, CA
Visited 8/16/78

NAME ED TERHAAR PHONE 916-445-6687
Organization Unit CA Dept. Water Resources
Title or Position _____
Specialty Resource Development/Energy

Location Sacramento, CA
Visited 8/17/78

NAME ALEX BLACK PHONE 415-893-3365
Organization Unit Geoproducs Corp.
Title or Position Executive Vice President
Specialty Geothermal Power

Location Oakland, CA
Visited 8/16/78

NAME ED STEENHOEK PHONE 916-445-6687
Organization Unit Dept. Water Resources
Title or Position _____
Specialty Resource Development/Energy

Location Sacramento, CA
Visited 8/17/78

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

Figure 2-46. Key Personnel Contacted, Wendel Amedee/Geoproducs/DWP/55 MWe

2.1.16 Lassen KGRA

Figures 2-47 and 2-48 present the General Information Summary and Key Personnel Contacted for this KGRA. It is located in Tehama and Plumas Counties in Northern California. No power plants are now being planned for this KGRA. Only two geothermal wells have been drilled there. One was unsuccessful. It was plugged and abandoned. The other was deepened recently from 1285 ft to 4000 ft by Phillips Petroleum, but the data on it are proprietary. It was drilled on private land.

The Tahoe National Forest Supervisor's Office together with the Bureau of Land Management are preparing an Environmental Assessment Report for leasing the federal lands of the KGRA which include a small part of the Tahoe and Plumas National Forests. It is scheduled to be completed in March 1979.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Location	Tehama and Plumas Counties, N. Ca.	98/6
Present status	No power plant planned	
Geothermal Wells Drilled	1 by Geyser Steam Co., 8/62 in Plumas County, "Shasta Forests #1", 1285'.	82/7
	1 by Phillips Petroleum 12/73 in Sierra Valley, Plumas County, "Fillippinni-A1", 223 ft. It was plugged and abandoned.	99
	Plumas County issued a permit to Phillips Petroleum, 11/77, to deepen the Shasta Forests #1 well to 4000 ft. It was drilled but it is a "tight hole" (information regarding it is proprietary).	97
		99
Other activity	BLM and USFS are preparing an EAR for leasing in the Beckwourth KGRA which includes a small part of the Tahoe and Plumas National Forests. It is due to be completed 3/79. The Tahoe National Forest Office is the lead agency.	
Potential	MWe (30 yr) 150 (USGS, '75), 1000 (ERDA, '77)	1/1-17

Figure 2-47. Lassen KGRA General Information Summary (As of 11/8/78)

NAME Al McGreeham PHONE (916) 283-2000
Organization Unit Plumas County Planning Dept.
Title or Position Environmental Planner
Specialty _____

Location _____
Visited _____
Telcon 11/8/78 (Ref 97)

NAME George Robson PHONE (916) 527-2200
Organization Unit Tehama County Planning Dept.
Title or Position _____
Specialty _____

Location _____
Visited _____
Telcon 11/8/78 (Ref 101)

NAME R.L. Wright PHONE (801) 364-2083
Organization Unit Phillips Petroleum
Title or Position Land Manager
Specialty _____

Location _____
Visited Salt Lake City, Utah
Telcon 11/8/78 (Ref 99)

NAME John Corbitt PHONE (916) 265-4531
Organization Unit Tahoe National Forest
Title or Position Realty Officer
Specialty Preparation of EAR

Location Nevada City
Visited _____
Telcon 11/8/78 (Ref. 102)

NAME Tim Caroli PHONE _____
Organization Unit BLM
Title or Position _____
Specialty _____

Location Susanville, Ca.
Visited _____

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

Figure 4-4-1. Lassen KGRA Key Personnel Contacted

2.1.17 Glass Mountain KGRA

Figures 2-49 and 2-50 present the General Information Summary and Key Personnel Contacted for this KGRA. It is located in Siskiyou County which is adjacent to the Oregon border. No power plants are planned there at the present time. No geothermal wells have been drilled there on private lands or on federal lands in the Klamath National Forest, although the USGS has some shallow temperature gradient wells in the latter area. No applications for drilling have been received by the County Planning Office (for private lands) nor by the Klamath National Forest Office, although the latter has received 20-25 lease applications. They have completed the rough draft of the Environmental Assessment Report. The Environmental Statement which is required in addition to the EAR is scheduled to be completed in 1980. The decision to lease or not lease is scheduled for late 1980.

Efforts are being made to determine the status of geothermal wells, if any, in the part of the KGRA in the Shasta Trinity National Forest.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Location	Siskiyou County, N. Ca. near Or. border	98/6
Present status	No power plant planned	
Geothermal wells drilled	None prior to 1975 (USGS geothermal well report) No applications for drilling any geothermal wells have been received by the County since then. However, the KGRA is on Federal land and drilling applications would be submitted to BLM or USFS (Klamath and Shasta National Forests). The Klamath National Forest Office has not received any applications to drill yet but 20-25 lease applications have been received. A rough draft of the EAR has been completed and the ES is scheduled to be completed in 1980. A go/no-go decision on the leasing is scheduled for 1980. USGS has some shallow temperature gradient wells there.	83 100 103
Potential, MWe (30 Yr.)	Unknown	

Figure 2-49. Glass Mountain KGRA General Information Summary (As of 11/7/78)

NAME Ted Coffin PHONE (916) 842-3531
Organization Unit Siskiyou County Planning Dept.
Title or Position _____
Specialty _____

Location Yreka, Ca.
Visited _____
Telcon 11/8/78 (Ref 100)

NAME Larry Larson. PHONE (916) 842-2741
Organization Unit Klamath National Forest
Title or Position Land Officer
Specialty _____

Location Yreka, Ca.
Visited _____
Telcon 11/8/78

NAME _____ PHONE (916) 246-5222
Organization Unit Shasta Trinity National Forest
Title or Position _____
Specialty _____

Location Redding, Ca.
Visited _____

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

NAME _____ PHONE _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Visited _____

Figure 2-50. Glass Mountain KGRA, Key Personnel Contacted

2.1.18 Surprise Valley KGRA

Figures 2-51 and 2-52 present the General Information Summary and Key Personnel contacted for this KGRA. It is located in Modoc County which is adjacent to the Oregon and Nevada borders. There are no plans for a power plant there at the present time. A total of ten geothermal wells have been drilled there and they are shown on the California Division of Oil and Gas maps (Ref. 78). Three of these wells have been abandoned and the remainder are idle. Magma Energy owns five of these but has no plans to do anything at this KGRA until the Magma 10MWe power plant at East Mesa is operational (Figure 2-18). The temperature of the Phipps #2 well is 362°F (183°C) according to the Munger Oilgram Record for this well (Ref. 79). This is almost as good as the 365-385°F well temperature for the East Mesa plant.

Gulf Oil owns one idle well but its temperature is only 300°F. They would like to drill closer to the Magma site but have a budget problem. Use of the geothermal loan guarantee program was suggested to Gulf by SDC and they will investigate it.

Geothermal Power Corporation owns two wells, one of which was abandoned but is usable as an injection well. They have recently been selected to negotiate with DOE for an agricultural center where feed for hogs would be grown in environmentally controlled grass growing machines that use geothermal energy as a source of heat.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>	
Location	Near Lake City, Modoc County, NE CA	80	
Present Status	Magma Energy and others have drilled wells as shown below. Magma has no plans to do anything here until the power plant at E. Mesa is operational. Gulf Oil is interested in further exploration.	80 81	
<u>Operator/Well Name</u>	<u>Status</u>	<u>DOG Map Sec.</u> <u>Date Drilled</u> <u>Depth</u> <u>Down-hole T</u>	
Magma Energy/Phipps 1	Idle	24 9/62 1267 ft.	73, 82
Magma Energy/Phipps 2	Capable of steam production	23 10/74 4946 ft.	78, 79
Magma Energy Parman 1	Idle	24 7/59 2150 ft.	78, 82
Magma Energy Parman 2	Idle	24 7/59 1968 ft.	78, 82
Magma Energy Parman 3	Idle	24 3/62 92 ft.	73, 82
Magma Power/Hapgood 1	Proposed - not drilled	14	78
Gulf Oil/Surprise Valley 1	Idle	30 9/73 6841 ft.	300°F 78, 79
Gulf Oil/Surprise Valley 2	Abandoned	13 10-23 6805 ft.	79, 82
Amer. Therm. Res./ Goodwin 1-11	Abandoned	11 12 74 7000 ft.	79, 82
Geothermal Power Corp. Kelly Hot Springs 1	Idle	27 7 74 3400 ft.	245°F 79, 82
Geothermal Power Corp. Kelly Hot Springs Ranch 1	Abandoned, but usable	29 5 69 3206 ft.	79, 82
Reservoir potential	2100 MWe (USGS, '75); 2000 (ERDA '77)		
Major Problem Area	Gulf Oil has a budget problem regarding further exploration A loan under the Federal GLGP is recommended		

* Field Operator contacted

Figure 2-51. Surprise Valley KGRA General Information Summary (As of 11/10/78)

Name Richard Foss ²¹³ Phone 483-5542
Organization Unit Magma Energy, Inc.
Title or Position Project Manager
Specialty _____
Location Los Angeles, Ca.

Name Glen E. Campbell ³⁰³ Phone 758-1700
Organization Unit Gulf Oil Mineral Resources Co.
Title or Position _____
Specialty Geothermal Exploration
Location Denver, Colo.
Telcon 9/26/78 (ref 81)

Name Frank G. Metcalfe ⁴¹⁵ Phone 897-7833
Organization Unit Geothermal Power Corp.
Title or Position _____
Specialty _____
Location San Francisco, Calif.
Telcon 11/10/78(ref 107)

Name Mr. Munger ²¹³ Phone 776-3990
Organization Unit Munger Oil Gram
Title or Position President
Specialty Oil, gas and geothermal well data.
Location Los Angeles, Ca.
Telcon 9/1/78

Name Doug Stockton ⁹¹⁶ Phone 445-9686
Organization Unit Ca. Div. of Oil and Gas
Title or Position Head of Geothermal
Resource Office
Location Sacramento, Calif.
Telcon 8/21/78

Name Vito Magliano ⁴¹⁵ Phone 273-7943
Organization Unit DOE-SAN
Title or Position _____
Specialty Loan Guarantee Program
Location San Francisco, Calif.
Telcon 9/26/78

Figure 2-52. Key Personnel Contacted, Surprise Valley KGRA

2.1.19 Diablo Area

Figures 2-53 and 2-54 present the General Information Summary and Key Personnel Contacted. It is located in the Diablo Mountain Range on the border of San Benito and Santa Clara Counties, due east of Monterey Bay. This area is not included in the USGS Circular 726 (Ref. 95) which lists geothermal reservoirs in the U.S. with subsurface temperatures greater than 90°C. Mercer Hot Springs is the closest geothermal area listed and its indicated subsurface temperature is only 125°C.

Diablo Exploration Company in Oakland did some surface geological exploration including the dating of volcanics in the Diablo Mountain Range about two years ago. The owner of the company believes it has geothermal potential, but is unwilling to disclose the results of the exploration without payment for the information. He says there are some shallow wells there in which they measured the temperature, but he would not disclose the name of the owner(s) of the wells.

The San Benito and Monterey County Planning Departments were contacted and they have received no applications for permits to drill any geothermal wells. The area doesn't appear to be worth further investigation as a site for a geothermal power plant.

ITEMDATAREF/PAGE

Location	In the Diablo Mountain Range on the border of San Benito and Santa Clara Counties, east of Monterey Bay.		
Status	Diablo Exploration Co, in Oakland, did some surface exploration there and dating of volcanics 2 years ago but is unwilling to disclose the results of the exploration without payment.	92	
Other Sources of Data	USGS Circular 726 does not even list the area under KGRAs with $T > 90^{\circ}\text{C}$. Mercer Hot Springs is the closest geothermal area listed (on the border of San Benito and Fresno Counties) but its surface $T = 46^{\circ}\text{C}$ and its estimated subsurface T is only 125°C		
	No applications for drilling geothermal wells have been received by either San Benito or Monterey Counties. No geothermal wells have been drilled in the area prior to 1975.	95/30 93, 96 82	102
Recommendation	Does not appear to be worth further investigation as a site for a geothermal powerplant.		

Figure 2-53. Diablo General Information Summary (As of 11/7/78)

Name Pete Castellanos Phone 415-893-7009
Organization Unit Diablo Exploration Company
Title or Position Owner of company (now defunct).
Specialty _____

Location Oakland, CA
Telephone Conversation: 9/6/78 (Ref.92)

Name Dale Ellis Phone (408)422-9018
Organization Unit Monterey County Planning Dept.
Title or Position Planner
Specialty _____

Location Salinas, Ca.
Telcon 11/8/78 (Ref 96)

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____

Name Phillip Zitsbuck Phone 408-637-5313
Organization Unit San Benito County Planning Department
Title or Position Manager
Specialty _____

Location _____
Telcon 11/7/78 (Ref 93)

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____
Telephone Conversation: 10/19/78

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____

Figure 2-54. Key Personnel Contacted. Diablo Area

2.1.20 Hawaii 3MWe Demonstration Power Plant

Figures 2-55 and 2-56 present the General Information Summary and Key Personnel Contacted for this small demonstration power plant. It is located at Puna, Hawaii on the rift in the east slope of Kilauea Volcano. The well drilled there from which power will be generated has the highest downhole temperature of any geothermal well in the world (358°C). The plant is scheduled to start producing power in August 1980, operate for two years, and then be removed at DOE option.

The plant cost of \$6.2M is being funded mostly by DOE (91.6%) with Hawaii contributing 6.4%, the county 1.6% and the Hawaii Electric Light Co. (HELCO) 0.4%.

HELCO is reluctant to locate a commercial power plant at this site which is on land which was recently overflowed with lava since the potential for recurrence of volcanic action in the area is high. Without complete financial protection for the plant and a standby source of power, it seems that HELCO will not pursue the development of a larger plant there, even if the demonstration plant is successful. Success of the latter is a very good possibility due to the high temperature and low dissolved solids (300 ppm versus 35000 for sea water) which are advantageous from the standpoint of low power cost.

Rogers Engineering (designers of the 3 MWe plant) believes that the risk can be greatly reduced by locating the commercial plant one to two miles from the rift and by using well locations, spacing and piping designed to minimize the percentage of wells which could be destroyed due to volcanic and seismic activity along the rift. The plant can also be protected from lava flows by properly locating it with respect to natural barriers and by effectively using the protection afforded by elevated ridges. This concept is based on experience with geothermal power plants they have designed in Iceland, where eruptions have occurred as little as two miles from a plant and faulting in the vicinity of the wells has resulted in the loss of only two out of eleven wells. It is recommended that a study be made of the feasibility of doing this for the commercial plant at Puna. Another possibility is the use of a

different site. Gedco is drilling an exploration well on the Kona Coast in a safer region. Helco is very interested. They now have a capability of generating 102 MW but most of it is fueled by oil (37% is from bagasse). They would like to replace the oil by geothermal energy, if possible.

<u>ITEM</u>	<u>DATA</u>	<u>REF/PAGE</u>
Location	Puna, Hawaii, HI. (E. slope of Kilauea Volcano).	
Schedule on line date	August 1, 1980	218
Well/Plant Operator	Hawaii Electric Light Company (both)	125
Cycle	Single flash	219
Present Status	Plant being designed by Rogers Engineering and Harai Associates. Construction to start 2nd quarter 79, generator 3rd quarter '80. To be operated for 2 years and then be removed at DOE option.	219 224
Plant EIR Status	State EIS completed, Federal EIS being prepared.	219,220
Plant cost	\$6.2 M	219
Funding	DOE 91.6%, State 6.4%, County 1.6%, HELCO .4%	219
Power cost, mills/Kwhr.	Not yet known.	
Number of wells drilled	One, HGP-A	125
Additional required	None	217/1
Bottom hole T	358°C (676°F)	217/2
Flow rate	101K lbs/hr., increasing each test	125
Dissolved solids	1500 ppm	126
Depth	6450 ft.	217/2
Reservoir Potential	500 MWe (speculation-reservoir is unproven).	222/9
Water Source Status	No outside makeup water required.	219
Transmission Line Status	Existing adjacent HELCO line to be used.	219
Major problem area	Volcanic activity is a hazard to a power plant. R & D is underway on the problems of H ₂ S abatement, noise abatement and geothermal fluid disposal.	

Figure 2-33. Hawaii/HELCO /HELCO 3 MWe Power Plant General Information Summary (As of 2/14/79)

Name Louis P. Lopez Phone 808-948-6920
Organization Unit HGP Wellhead Generator Project
Title or Position Project Manager
Specialty _____

Location Honolulu 1110 University Avenue
Visited: 8/18/78 and 10/3/78

Name E. Chipman Higgins Phone 808-548-7721
Organization Unit Hawaii Electric Light Company
Title or Position Director, Energy Supply
Specialty _____

Location Honolulu, 820 Ward Avenue

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____

Name Roy T. Uemura Phone 808-548-7771
Organization Unit Hawaii Electric Light Co.
Title or Position Technical Monitor
Specialty _____

Location Honolulu, 820 Ward Avenue
Visited 9/26/78

Name Don Thomas Phone 808-948-7654
Organization Unit University of Hawaii
Title or Position _____
Specialty Well Testing

Location _____

Name _____ Phone _____
Organization Unit _____
Title or Position _____
Specialty _____

Location _____

Figure 2-56. Key Personnel Contacted, Hawaii/HELCO/HELCO/3 MWe

APPENDIX A

DATA FOR GEOTHERMAL WELLS IN THE IMPERIAL VALLEY

Figure A-1 presents data for these wells which were compiled from the Lawrence Berkeley Laboratory Report LBL-5936, dated May, 1978 (Ref. 109). It shows the well record number assigned by LBL, the well name, well owner, California Department of Oil and Gas map section number, the date drilling was completed, well type (abandoned, suspended, production, injection, observation), depth, maximum temperature, maximum flow rate (thousands of pounds/hour), total dissolved solids (parts/million) and enthalpy of the fluid (calories/gram).

Salton Sea KGRA Wells

<u>Rec. No.*</u>	<u>Well Name</u>	<u>Owner</u>	<u>Map Sec.</u>	<u>Date Compl.</u>	<u>Well Type</u>	<u>Depth Meters</u>	<u>Max T °C</u>	<u>Max Flow 103lbs/hr.</u>	<u>TDS ppm</u>	<u>Enthal. Cal/g.</u>
228	Dearborn-ME 1	Magma Energy	30	1/72	Aband, dry	1260				
229	Dearborn-RGI 1	Republic Geo.	30		Prod.					
230	Elmore 1	Magma Power	27	5/64	Prod.	2170	360	316	318000	285
231	Elmore 3	Imperial Magma	27	4/74	Susp.	761				
232	Hudson 1	Magma Power	13	7/64	Aband. 71	1864	260	432	308000	225
234	IID 1	Imp. Thermal Prod.	23	8/62	Aband. 77	1591	316	625	258000	
252	IID 2	Imp. Thermal Prod.	22	12/63	Aband. 77	1769	330	440	259000	235
256	IID 3	Imp. Thermal Prod.	23	3/65	Aband. 77	517	200		347000	
257	Landers 2	Republic Geo.	20	2/76						
258	Magmamax 1	Imperial Magma	33	1/72	Prod.	875	265	542	255000	250
262	Magmamax 2	Magma Power	33	11/72	Inj.	1329	278			
263	Magmamax 3	Magma Power	33	11/72	Inj.	1216	321			
264	Magmamax 4	Magma Power	33	12/72	Obs.	780	240			
265	Pioneer 3	Pioneer Dev. Co.	10	1928		449	68			
266	River Ranch 1	Imperial Magma	24	1/64	Aband. 71	2464	345	245	385000	250
268	Sinclair 1	Geo. Energy & Mineral Corp.	10	3/58	Plugged '59	1440				
269	Sinclair 2	Geo. Energy & Mineral Corp.	4	4/61	Aband. dry	722				
270	Sinclair 3	Geo. Energy & Mineral Corp.	10	4/63	Inj.	2110	280	593	183000	240
283	Sinclair 4	Geo. Energy & Mineral Corp.	4	6/64		1617	255		291000	210

*Numbers missing are for additional tests on same well.

Figure A-1. Data for geothermal wells in the Imperial Valley (Ref. 109) (Page 1 of 3)

Salton Sea KGRA Wells (cont'd)

<u>Rec. No.*</u>	<u>Well Name</u>	<u>Owner</u>	<u>Map Sec.</u>	<u>Date Compl.</u>	<u>Well Type</u>	<u>Depth Meters</u>	<u>Max T°C</u>	<u>Max Flow K lbs/hr.</u>	<u>TDS ppm</u>	<u>Enthal. cal/g.</u>
301	Sportsman 1	Imp. Thermal Products, Inc.	23	3/61	Aband, 77	1441	340	324	335000	220
303	State 1	Imp. Thermal Products Inc.	23	5/64	Prod.	1475	310	405	219500	280
305	Woolsey 1	Imperial Magma	33	3/72	Prod.	732	238		132000	

Brawley KGRA Wells

18	Wilson 1	Standard Oil	20	7/63	Aband., 63	4097	147		53700	
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East Mesa KGRA Wells

135	Mesa 5-1	U.S. Bureau of Reclamation.	5	5/74	Inj.	1829	170		1575	
138	Mesa 6-1	U.S. Bureau of Reclamation.	6	8/72	Prod.	2448	204	102	28110	
150	Mesa 6-2	U.S. Bureau of Reclamation.	6	8/73	Prod.	1830	187	118	5000	
156	Mesa 8-1	U.S. Bureau of Reclamation.	8	6/74	Prod.	1886	180		1600	
158	Mesa 31-1	U.S. Bureau of Reclamation.	31	6/74	Prod.	1894	157		2900	
160	Mesa 16-29	Republic Geo-thermal Inc.	29	12/75	Prod.	2445	162	419	1978	
161	Mesa 38-30	Republic Geo-Thermal Inc.	30	10/75	Prod.	2746	176	670	1907	
162	Mesa 18-28	Republic Geo-Thermal Inc.	28	1/76	Prod.	2439	162	36	2950	

*Numbers missing for additional tests on same well.

Figure A-1. Data for Geothermal Wells in the Imperial Valley (Ref. 109) (Page 2 of 3)

Heber KGRA Wells

<u>Rec. No.*</u>	<u>Well Name</u>	<u>Owner</u>	<u>Map Sec.</u>	<u>Date Compl.</u>	<u>Well Type</u>	<u>Depth Meters</u>	<u>Max T^oC</u>	<u>Max Flow K lbs/hr.</u>	<u>TDS ppm</u>	<u>Enthal. Cal/g.</u>
163	Holtz 1	Magma Energy Inc.	32	4/72					13168	
164	Holtz 2	Magma Energy Inc.	31	6/72					16330	
165	Jackson 1	Chevron Oil Co.	32	9/74					15430	
167	Nowlin 1	Chevron Oil Co.	33	11/72					14100	

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APPENDIX B

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