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RESERVOIR AND SITE

PON CRITERIA

Criteria			BROWN
SUITABILITY			
o Reservoir			
- Energy Content			
(Plant)	50 MW/5 yr	NO PROBLEM	"The Heber prospect is of moderate size and marginal temperature. The geothermal reserves at Heber are clearly great enough to support the plant as planned. With enough financial support, we see no major risk that one 50 MW3 plant cannot be made to work" (USGS, p.1)
	50 MW/30 yr	NO PROBLEM	Projected temperature drop will require increased fluid flow rate and possible modifications of plant (pumps, heat exchangers, turbine inlet temperature).
	Multiple Plants		"At least several additional plants of the same type are likely from the same reservoir, although there are considerable risks that: (1) The expansion possibilities are less than projected by the offeror, and (2) The costs of the required new technology will not be competitive with alternative sources of power (including other geothermal fields in the Imperial Valley)."

SCE/Chevron	Heber	50 MWe	1981?	Flash
Republic Geothermal	E. Mesa	10&54 MWe	1979-80	Dual Flash DOE Loan Guaranty
MAGMA	E. Mesa	10 MW3	1978-9	Binary
Union	N. Brawley	10 MW3	198_	

- Other

o Temperature	330-360°F (USGS)	"Marginal temperature, utilizing the leading edge of technology (for reservoir development (drilling islands; deep downhole pumps; high production and injection flow rates) and plant design)." Isherwood - USGS 2-17-78

o Salinity

10-30,000 PPM Data poor (USGS)
"Cooling the geothermal fluid in the heat exchangers may lead to precipitation of small amounts of iron sulfides....and possibly traces of (copper-iron and lead sulfides). Small amounts of (barium sulphate) may also accumulate with time. Accumulation rates of these phases cannot be estimated with available data, but will probably be small. Their effect on heat transfer coefficients therefore, is not determinable. Similar precipitation phenomena may also occur in injection wells and pipelines....No significant carbonate or silica precipitation, scaling or plugging problems (are expected) with downhole pumped cycle as described. No silica problems with self-flowing cycle described; possible carbonate scaling in production wellbores. Some deposition of calcite at the thermal front near reinjection wellbores. No significant post-reinjection silica deposition." (LBL P12-13, DRAFT)

o Deliverability (Production Flow Rate)

A very large question at Heber. Development requires 45,000 B/D pumped flow rates from each well. Only 10,500 and 16,000 B/D have been demonstrated. Esixting wells may have been damaged by use of improper drilling and completion techniques * forcing their abandonment. "The reservoir... appears to be capable of delivery of large mass flows to the GDPP over a 30-year period. However, possible drawdowns in the production wells for the flow rates envisaged (e.g., 45,000 bbl/day) needs careful consideration. The drawdowns will govern the pumpsetting, which in turn will have influence on...the depth at shich directional drilling could be commenced, and...the cost of lift....Nor is any data available on depth for setting the pumps. It is therefore difficult to estimate whether the 12 proposed wells will, in fact, deliver the required fluids at acceptible drawdowns." (LBL P11, Draft).

Chevron plans to continue using Bentonite Gel drilling mud with cemented jet perforated casing at Heber (Vol II, P16). They do not mention drilling with balanced pressure (formation fluid pressure = mud column pressure). At East Mesa in Imperial Valley, similar drilling techniques have seriously damaged geothermal wells of similar temperature (335oF) and lower salinity (1,600 PPM). Senior researchers from the USGS (P. Muffler, R. Truesdale, M. Nathenson and A. Fornier) have reviewed proprietary data from the DOE Guaranteed Loan to Republic Geothermal, Inc. at East Mesa and agree that severe long term reduction of initial flow rates by 75% results from:

(1) Drilling with Bentonitic "Gel": Montmorillonite clay) mud damages the producing horizon by:

- o Injection deep into porous sands by overpressure, and
- o Hardening of the "Gel" mud cake over time, causing permanent impairment

(2) Use of slotted liner in the open hole for well completion, rather than cemented and jet perforated solid casing. Unless the liner is cemented, acidizing and fracturing workovers are not effective, and

(3) Failure to immediately flow the wells at very high rates for long periods, to flush drilling mud from the formation before it can harden permanently.

Chevron may be unaware of the flow rate impairment problems resulting from Bentonitic Gel Muds, or may be walking away from the 15 existing wells in the Heber area because of long term (6 mo-2 yr) decline in flow rates. This data is proprietary to Republic Geothermal, protected under Public Law 93-417, and cannot be transmitted to Chevron or other operators. Detailed, long duration (1-2 Mo.), current flow pump test data from the Heber wells, and analysis by USGS and LBL, is required to resolve this issue.

° Downhole Pumping

(Production Wells)

Flow rates required at Heber require downhole pumping, with pumps set deeper (minimum 1,100 ft at 45,000 B/D) to prevent cavitation than is known to have been accomplished anywhere in the world. Modified irrigation well pumps are capable of such high flow rates, but operation at geothermal temperatures creates major shaft bearing and bowl clearance problems. Reliable geothermal downhole pumps are not known to be available. To date maximum pump depths of above 500 feet have been achieved, with major failures, in geothermal wells at East Mesa by Magma and Republic. "As productivity indices decline, pump depths will need to be lowered to the threshold of current technology." (LBL PI-5, Draft).

This does not mean that the Heber Field is unusable, but will probably mean major modifications in the development schedule - such as downhole pump R&D and additional wells.

° Injectability

(Injection Wells)

Potentially moderate scaling of the reinjection pipeline and injection wellbore is anticipated by the USGS; plugging of the formation is uncertain (P I-8, Draft). LBL expects the extent of these problems to be small (P1-8, Draft). Fluid disposal is expected to be adequate, but the amount of fluid to be put away and the required injection pressures raise questions with the adequacy of the number of injectors. "The planned injection rate is approximately 86,000 B/D (per injection well). Simple extrapolation of the Holz No.2 data to the anticipated injection (rates) will suggest injection pressures of 1,200 psi or more. It is therefore not clear how the injection scheme is prepared to be carried out at approximately 250 psi as the proposers indicate." (LBL P11, Draft). Such high injection pressures may fracture the reservoir rock, causing earlier breakthrough of cooled waters into the production wells.

Longevity (Plant) - Thermal Recovery (Heat Sweep)

"In principle, the Heber reservoir, being a pourous medium (with some fractures) is suitable for optimal injection schemes to repressure the reservoir as well as to sweep heat from the rock. The proposal for the Heber Demonstration Plant envisages reinjection in an area about 1½ to 2 miles northwest of the producing area. As a result, its effect on repressuring the

reservoir as well as to sweep the heat towards the production wells appears to be small. (A more efficient sweep of heat from the rock may be obtained if a ring of injection systems is eventually developed around the producing region. But no optimal sweep is expected until their long-term grand plan is ever carried out.)" (LBL P11, Draft)

Field Development Plan

SDG&E does not disclose Chevron's plans for how the directional drilling will be done. The Government doew not know where the production and injection (completion) interval will end up at depth. There are two serious problems associated with Chevron's island drilling proposal:

- Drilling Technology - Use of directional drilling (whipstocking) from production and injection well islands in an experimental field development technique. While rugged terrain has forced Union to drill several wells from a single pad at the Geysers, the Heber area is perfectly flat. Magma, Republic, Phillips and others have drilled many wells in agricultural farmland throughout the Imperial Valley using conventional individual well sites. Forty inch reinjection pipeliens, raised on supports, will zig-zag miles to the injection well islands on the full field development plan (Vol. II Fig II 2-34, P69). These could share right-of-way with conventional production pipelines.

  Technical problems are significantly increased with the cramped conditions and elevated temperatures proposed for Geothermal island drilling. The primary purpose appears to be to eliminate the surface collection pipeline, and associated temperature losses (and scaling problems).

- Downhole Pump Setting Depth - Downhole pumps must be emplaced in vertical sections of the wellbore casing to permit insertion and withdrawal. Directional wells cannot be whipstocked toward their target until this vertical section, near the surface, is passed. No data is available on the depth for setting the pumps. The drawdowns resulting from required flow rates will govern the pumpsetting. However, those drawdowns will fall over time from declining flow rates and multi-well interference effects. In turn, these factors influence the depth at which directional drilling could be commenced, and the cost of lift (parasitic pumping losses).

Access and Control

The Heber site is a checkerboard of leases held by Chevron, Union and others. SDG&E has no control over the reservoir, except through NARCO, their subsidiary, which has leases for about 5% of the proposed Unit Area. Union controls about 40% of the Unit Area, including four wells. Chevron holds more than 50% of the acreage, including seven wells. (Vol II Fig. II 2.1, P 45). It is not certain that Chevron will be the field operator, if and when the Heber area is unitized.

The SDG&E option for the plant site, through their JAPATAL subsidiary, expires June 16, 1978.

- Site

  - Availability of Cooling Water

First Five Years: Adequate irrigation water has been promised by the Imperial Irrigation District. However, water losses from the increased density of the cooler reinjected fluid will not be made up.

After Five Years: Major problem. Irrigation water supply is not committed by the Imperial Irrigation District, which is negotiating to supply cooling water to other geothermal plants in the Imperial Valley in the same time period. The District offers agricultural drain water of much higher salinity and uneven flow, although the quantity is extensive. Increased salinity may require treatment and/or plant modification. Uneven flow may require reservoir storage. The policy issue should be raised whether the objectives of the demonstration project are achieved when there is a complete change over in cooling water supply after the demonstration is completed.

- Other Pertinent Factors

NONE

CAPABILITIES OF OFFEROR TEAM

- Qualifications of Key Personnel

Very little is said in SDG&E's proposal with reference to Chevron and the reservoir team, or NARCO, their fuel supply subsidiary. "Chevron Oil Company has an extensive amount of experience in the production of hydrocarbon resources from reservoirs structurally similar to the interbedded sand-shale sequences found in the Heber geothermal field. Although Chevron has not commercially developed a geothermal resource and did not identify personnel responsible for reservoir studies, it can be concluded that there should be a successful transfer of their oil and gas experience and expertise to the development of the Heber Geothermal Field. (LBL P 15, Draft)

This is not seen as a serious problem, although there is some concern about Chevron's drilling practices (see "Deliverability", above).

- Relevant Experience

SDG&E's operation of the DoE Geothermal Loop Experimental Facility at Nilano has failed to integrate the surface (power plant) and subsurface (production and injection wells) elements of an interdependent project. As a result, the Facility is seriously affected by heavy scaling from the highway saline brines (300,000 PPM max.), and Imperial Magma's reinjection wells are plugging from uncontrolled precipitates and unfiltered debris from scale removal maintenance in the plant. The key individual in the Heber Proposal, Gil Lombard, was the project manager for the Nilano GLEF. The proposal is characteristic of SDG&E's trial and error approach at Nilano, which has led to an openended cost overrun without control by milestones measureable in terms of end results, estimated schedule, or cost to completion (see SAN Audit Report, January 1978).

DATA GENERATION AND INFORMATION DISSEMINATION (RESERVOIR)

- Soundness of Approach

"No substantive outline of the data collection for the reservoir has been made". (LBL P15 Draft) There is no evidence that SDG&E will prevail on Chevron to illuminate the geologic community on what is taking place in the Heber reservoir. All that will be delivered are copies of required DOG (Calif. St. Div. Oil & Gas) and USGS reports, and semiannual Chevron technical reports which are subject to the concurrence of Unit participants. "No plans have been made to insure the information will be easily available to interested parties....No bona fide willingness to provide available data on the reservoir has been indicated in the proposal itself." (LBL P15, Draft).

The content, timeliness and spirit of SDG&E's reservoir data and dissemination are unacceptable, and represent a major deficiency in the Heber proposal.

PROJECT INTEGRATIONAND RESPONSIVENESS (RESERVOIR)

°Responsiveness to objective

Three of the Project's seven objectives directly relate to reservoir activities:

- "Demonstrate....the readiness of state-of-the-art technology....using a low-to-moderate salinity liquid-dominated hydrothermal resource,

- Demonstrate reservoir performance characteristics of a specific liquid-dominated hydrothermal resource; (and)

- Demonstrate the validity of reservoir engineering estimates of reservoir productivity (capability and longevity)."

Successful accomplishment of these objectives will be a major contributor to a fourth Project objective:

"Provide a basis for the financial community to estimate the risks and benefits associated with geothermal investments."

The reservoir engineering risk of development and operation of the Heber geothermal wells is high, on the following basis:

Con - Marginal temperature resource,
- Experimental drilling (island) and completion (gel mud) techniques
- Requirement for downhole pumping at depths more than twice current (marginal) experience, and at very high flow rates (average 48,000 B/D)
- Limited duration pumped flow tests at rates approximately one-fifth the required production levels
- Requirement for disposal of high volumes of spent fluid at high pressures,
- Experimental geothermal reinjection (island) and heat sweep (donut) concepts, and
- Projected drop in temperatures of produced fluid will require increased flow rates, drawdown and downhole pump depths over 30 year life of plant.

Pro - Simple geologic structure (sand-shale pile)
- Comprehensive subsurface understanding of temperature distribution at depth (multi-level thermal contour maps)
- Control of most scaling and plugging problems by maintaining the geothermal brine under pressure, by pumping rather than flashing the fluid.
- Potentially efficient heat sweep, if the Heber leases are unitized, and if presently unknown fractures do not seriously affect the reinjection concept.

These factors add up to the likelihood of significant resource production delays in resolving state-of-the-art problems, with consequent schedule and cost overruns. The Project is not proposed as a commercial venture, and may contribute little, or negatively, to the financial community's confidence in geothermal investments.

o Level of Confidence in Success - Reservoir

SDG&E has isolated themselves from the reservoir production and reinjection by sub-contracting to Chevron.

BUSINESS EVALUATION CRITERIA TOTAL ESTIMATED COST
(RESERVOIR)

- Reasonableness of Proposed Cost

SDG&E is attempting to isolate itself from reservoir development and operation risks through the steam sales contract to Chevron. USGS suggests that Chevron will probably have to adjust this contract if difficulties are encountered.

Extensive reliance on innovative and unproven drilling and pumping techniques, at the threshold of geothermal technology, results in serious risk of delay. With adequate funding, there is no major risk of successful production and reinjection at the Heber reservoir to support the 50 MWe demonstration plant.

- Realism of Time Schedule

Most of the reservoir concerns at Heber impact the reasonableness of the proposed schedule. For example, the innovative downhole pumping scheme uses pumps which have not been tested at the depths and flow rates which are required at Heber. If the wells cannot be pumped as hard, as many as twice the number of wells may be required. This will further delay plant start-up and operation at full capacity.

Other Factors

- Past Performance

SDG&E is inexperienced in the design and management of R&D projects. On the Nilano Geothermal Loop Experimental Facility (GLEF) project for DOE, ..."Technical problems, such as scale control and removal, and injection well plugging....were not revealed during the testing. Consequently, the facility was not designed for scale removal and clean-out, so extensive hardware modifications were required. GLEF project personnel agressively pursued potential solutions as technical problems were encountered, requiring a trial and error approach when engineering data were not available. For example, project participants have been attempting to devise a method for cleaning the injection brine to prevent injection well plugging. Imperial Magma and SDG&E experimented with slotted liner pipe "strainers" (SDG&E expense) and metal shaving filters (Magma expense) which proved to be ineffective...The problem is still not fully resolved....Future efforts to resolve the plant scaling and injection well plugging problems could result in additional scope changes and costs." (P14, Management Review and Appraisal of the San Diego Gas & Electric Co. Geothermal Loop Experimental Facility (Contract 1137), Office of Management Review and Audit, SAN/DOE, February 1978, cc M. Scheve, GED/DOE HQ).

"Estimated cost to complete project objectives is not known: (P2, 1B1D.)

- Proposed Cooperative Arangements

The GLEF Facility was not designed and is not operated today as an integrated system with the geothermal reservoir at Nilano. The fluid chemistry of the geothermal brines produced by Imperial Magma's wells controls the operation and resultant scaling of the surface plant. In turn, the operation of SDG&E's plant controls the chemical precipitation and release of scale debris during maintenance, with the resultant plugging of Imperial Magma's injection wells.

Unified management of the surface (plant) and subsurface (production and injection) operations is required because a geothermal reservoir and plant form an integrated system. Brine production, utilization and disposal inexorably links the generation of power to the unique characteristics of that site. One cannot be optimized without impacting the other.

On the basis of SDG&E's cost and schedule overrun at Nilano, it would be unwise to permit a similar, non-integrated, sub-contract relationship with the reservoir operator at Heber.