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REVIEW OF GKI COUNTERPROPOSAL TO WILLIAMS AFB RFP ON GEOTHERMAL ENERGY DEVELOPMENT

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Summary and Conclusions

On the surface, the Geothermal Kinetics counterproposal to the Williams AFB shows little or no economic advantages for the USAF. Williams AFB is currently buying electrical power at an extremely favorable rate, compared to the U.S. average, as reflected by their FY-1980 average cost of 31 mills/kWh. The probable cost of power from the 25MW(e) power plant proposed by GKI is in excess of 109 mills/kWh for 1981, and would escalate by about 10%/year for a 1984 cost of 145 mills/kWh, the earliest reasonable date for the plant to come on line. It is unlikely that GKI either could or would discount the price of power from this plant significantly for Williams AFB.

The other aspect of the Williams AFB RFP which was not addressed in the GKI counterproposal, a straight space cooling system, was also examined for its feasibility and potential consideration by the USAF. If our estimation of the total amount of electricity consumed by 3300 tons of conventional airconditioning is correct, this concept does not appear economically attractive to the USAF either, as a capital investment of approximately $\$13 \times 10^6$ is required to save an estimated $300,000 per year of electricity at current prices. However, several extenuating circumstances may make this alternative attractive to the USAF. For this reason, the following additional comments resulting from the proposal review are provided for USAF consideration.

Economics

Section IV.2.b. of the RFP specifies the requirements for a business proposal. The GKI proposal does not even address the life-cycle cost requirements (Criterion 9), and their proposed "cost-share" program (Criterion 8) is unrealistic. They do not provide a detailed utility pricing plan and they do not describe the method of financing the non-government share of the project.

GKI's estimated cost for Phase I is $1,447,000. The Air Force's share will be $1,000,000 whether or not the well is successful. The criteria for success are not defined in specific well characteristics, as required by the RFP. However, a general success criterion - capable of producing 3MW(e) is proposed. In my opinion, their cost proposal is not responsive to the RFP's call for a variable cost-share plan related to the success of the well. GKI goes on to propose that additional wells be drilled to confirm the reservoir's potential, but no cost estimate is given for this phase of the project. They assume, without providing justification, that an economical project must exceed the AFB electrical energy requirements by a factor of two, and they base their Phase II cost estimates on a 25MW(e) project. A project of this size would require at least eight successful wells. The capital cost estimate for Phase II is $29,560,000 excluding the cost of the wells. No cost estimate is provided for the wells. The cost estimate for the items they include in Phase II is low because interest during construction is based on a 7% interest rate, which is unrealistic in the near future. The proposal does not include any operating or maintenance cost estimates for Phase II of the project.

GKI proposes to sell the AFB electricity at "avoided costs." They would sell the balance of the plant's output to a utility at the same rate. I have two problems with this. Utilities obtain new capacity and energy at marginal rates (avoided costs) and sell at average rates. It would be very unusual for a utility's marginal rate to be lower than its average rate. In essence, GKI proposes that the Air Force obligate to buying power at the marginal rate for 30 years. My second problem also relates to selling power and energy to the Air Force and a utility at the same rate. Simply put, the Air Force will put up a million dollars and get no special benefit from having done so. The utility has no investment and gets a greater percentage of the plant output at the same rate as the Air Force. Perhaps the utility should be approached on making this a joint venture.

The base currently buys energy at an average rate of $.031/kWh. Although GKI does not present an economic analysis, they claim to be able to save the Air Force about 10% on this rate (as escalated I presume). This is naive. There is no way they can provide electrical energy this cheap from a 10,000-foot-plus geothermal resource. The capital cost of the electric plant alone (excluding well costs and development costs), amortized over 30 years assuming a 12% interest rate and an 85% plant factor, would require $.023/kWh in debt service. And it is doubtful that long-term financing could be found on such favorable terms. Because avoided cost rates can be volatile at the PUC's discretion and because the PURPA legislation which requires utilities to buy at the avoided cost rate is currently being challenged in the courts, few lending institutions will commit funds without a long-term purchase agreement. This is what the Air Force requested in their RFP, but the GKI proposal does not address the issue. They do not propose to make "definite commitments."

If GKI actually could save the Air Force 10% on its electrical bill over 30 years, the proposal would be acceptable to the Air Force. Assuming an annual demand of 49,517,000 kWh, 7% escalation, a 7% discount factor, a 30-year life, a 4-year construction period, and a savings of $.0031 per kWh, the present value of the savings is $4,600,000. Because this exceeds the present value of the Air Force's investment, $1,000,000, it would be the economical thing to do. In fact, the "internal rate of return" on the Air Force investment is approximately 15%.

GKI's economic analysis is clearly inadequate - even for this early stage in project development. They need to prove that their proposed project has a fair opportunity to be economically feasible before they proceed. To do so they must present an after-tax discounted cash flow analysis of their proposed project. They must also evaluate other obvious alternatives. One alternative is a 12MW plant to satisfy Air Force requirements only. Another alternative, which received only passing attention in the proposal, is a direct heat application providing the Air Force with its space heating needs. After all this was the Air Force's number one priority.

Utilization - Electric Power Plant - In its counterproposal to the Air Force RFP, Geothermal Kinetics has offered to build a 25MW(e) geothermal power plant and sell electrical power to the Air Force at "avoided cost" if the resource proves to be adequate. "Adequate" is defined in the proposal as a geothermal well which will produce 3MW(e) or more. An analysis was performed to determine the approximate cost of electricity from such a power plant. This analysis estimated the capital cost of production wells, injection wells, field surface equipment and power plant, and accounted for well, field equipment and power plant O&M costs. For a power plant startup in early 1985, the earliest feasible date for such a project, the power costs were determined to be approximately 109 mills/Kwh. Escalating the Williams AFB power costs for FY-80 of 31 mills to 1985 gives a power cost of approximately 55 mills/Kwh. Details of the capital cost determination of the geothermal field system and power plant are given in Table I. Power generation costs are developed in Table II.

Utilization Geothermal Space Cooling Plant - Although Geothermal Kinetics did not consider a space cooling plant in response to the Air Force RFP, such a scheme was evaluated to evaluate its potential. The total capital cost of the complete system is $\$13.28 \times 10^6$ 1981 dollars including geothermal wells. Some difficulty was encountered in trying to estimate exactly how much electricity would be saved by the 3321 tons of electrically powered airconditioning replaced by this system. From the assumptions that no airconditioning would be used in March, the month of minimum demand, and that the total difference in demand between June, the month of maximum demand, and March is due to airconditioning loads, it appears that about 40% of the total base airconditioning load would be served by the 3321 ton system, and the savings in electricity would be about $313,000 per year. However, if significant airconditioning is used in March, the potential for electrical cost savings could be significantly greater. The capital cost breakdown for this system is given in Table III. Subtotals have been included in Table III for each major system to simplify analysis which could apply credit for portions of an existing system which may be scheduled for replacement.

TABLE I

25MW(e) Field System and Power Plant Capital Costs
425°F Downhole Resource Temperature

	1982 Dollars	Costs Include Escal & IDC
Field System		
Production Wells (8 + 1 spare)	$\$17.1 \times 10^6$	$\$22.23 \times 10^6$
Injection Wells (4)	4.4×10^6	5.72×10^6
Field Surface Equipment ($230/KW)	5.75×10^6	7.13×10^6
Subtotal	$\$27.25 \times 10^6$	$\$35.08 \times 10^6$
Power Plant ($1312/KW)	$\$32.80 \times 10^6$	$\$40.67 \times 10^6$

TABLE II

POWER GENERATION COSTS
(80% Load Factor)

	Mills/Kwh
Field System Capital Charge (25% fixed cost of capital)	50.06
Well Maintenance	2.68
Field Surface Equipment O&M	4.56
Base Field Costs	57.30
Royalties (10%)	5.73
Subtotal "Fuel Costs"	63.03
Power Plant Capital Charge (18% fixed cost of capital)	41.78
Power Plant O&M	4.50
Subtotal Power Plant Costs	46.28
Total Power Generation Costs	109.31 mills/Kwh

TABLE III

CHILLED WATER COOLING SYSTEM CAPITAL COSTS (1981 Dollars)

Exploration & Wellfield development[1]	
Wellfield development:	
Production Wells (2) (1 spare production well)	$3,800,000
Reinjection Wells (1) (no spare)	1,100,000
Collection-Reinjection piping (including valves, instruments and controls and steam separator-scrubber)	1,105,500
Subtotal	$6,005,500
Plant Equipment:	
Single stage absorption chillers (3) (1 spare unit)	$ 795,000
Single cell open evaporative cooling tower (basin included, no recirculation pump)	120,000
Steam separator and steam scrubber	424,731
Pumps (2 reinjection wells with spare and cooling tower recirculation, no spare)	191,000
Instruments and controls	150,000
1000 ft^2 building (housing chillers, motor control center, master flow control and water treatment, $12 per ft^2)	12,000
Labor costs for installation of equipment and facilities (30% plant equipment)	585,219
Contractor mark-up and construction management (15% plant equipment installed)	380,392
Subtotal	$2,658,342
Chilled Water Transmission System:	
Transmission and return (10,560 ft dual pipe, buried and installed, $126.79 per linear ft, 24 in. x 50 ft. L.)	$1,338,902
Labor, assembly of transmission pipe (10%)	133,890
Recirculation pumps	70,000
Contractor mark-up and construction management (15%)	231,418
Subtotal	$1,774,210

TABLE III (Cont'd)

Chilled Water Distribution System:	
Site header and return (25,500 ft dual pipe buried and installed, $32.59 per linear ft 12" x 20 ft L.)	831,045
Site distribution and return (28,275 ft dual pipe buried and installed, $14.20 per linear ft, 4 in. x 20 ft. L)	401,505
Labor assembly of distribution pipe (10%)	123,255
Recirculation pumps	70,000
Contractor mark-up and construction management (15)	213,870
Subtotal	$1,639,675
Project design (5% plant equipment and chilled water transmission and distribution system)	$ 316,511
Contingency (10% plant equipment and chilled water transmission and distribution system)	633,022
Subtotal	$ 949,533
TOTAL	$13,027,260

1. Not required per Arizona State Bureau of Geology and Mineral Technology.

Exploration - Introduction

The DOE technical review committee suggests that, prior to a decision to continue the project by negotiating with GKI, the following inexpensive steps be taken to broaden the resource thermal and reservoir data packages available to USAF decision makers. Although thermal characteristics of the resource are more certain than permeability characteristics, it is important to obtain reliable thermal logs of both GKI wells. The RFP geologic report contains reference to a GKI-Group Seven log of Well I. which was made in 1979. This log should be reviewed. No post-1973 thermal logs are mentioned for Well 2. If such a log exists, it should also be reviewed. If no such log exists, the Air Force may wish to contract to have a log run.

Reservoir production characteristics are the major geologic concern in this program. GKI conducted well test data, gathered during 1973 activities, should be evaluated to determine any possible production characteristics.

The thermal and well test data should be inspected by USAF negotiations prior to any formal meeting with GKI.

The DOE review team suggests that the first meeting with GKI be devoted to reviewing the drilling history of the two wells. Special emphasis should be placed on lost-circulation zones, drilling procedures, or specific circumstances that could be interpreted to indicate possible geothermal production zones. In particular, there may be a zone at approximately 7000 feet that could meet USAF energy goals. This zone might be reached by "kicking off" at a shallower level in an existing well. This meeting should also be used to evaluate recent GKI geothermal drilling experiences. How they propose to handle drilling conditions in deepening the well is important.

The DOE review team estimates that new logging in the wells, and the meeting with GKI, should cost under $15,000. Once this money has been spent, it is appropriate for the Air Force to make a decision to either proceed with negotiations with GKI, redefine the program and sole-source a contractor, or reissue an RFP, or abandon the project.

The RFP left several resource development options open for selection by the proposed respondents. The GKI proposal addressed only one of these options. The DOE review team feels that, after data compilation and the first meeting with GKI, other options such as shallower on-base drilling, engineering redefinition, should be economically evaluated as part of the decision process addressed above.

<u>Exploration - Resource</u> - The lack of a geological exploration in this proposal should not be interpreted to mean that there are no geological uncertainties connected with the program. There are two main concerns from a geological point of view: will the predicted temperatures be encountered, and will there be commercially producible fluids?

The question of the expected temperature has two facets. The first is the thermal regime of the existing wells, and the second is the expected temperature regime at depth. The highest bottom-hole temperature reported in the proposal is from Group Seven, who are cited (without including a copy of the log) as having measured 196°C from well 1 in 1979. The earlier (1973) reported temperature for this well is 128°C; this early number may not indicate equilibrium temperatures. If the 196°C temperature is accurate, and if a gradient of 25°C/Km is projected to depth, then the USAF and GKI may well encounter the proposed 425°F (218°C) target. A new temperature is not reported for well 2. The old bottom-hole measurement is 178°C, which may not have been recorded at equilibrium thermal conditions. If the old temperature from well 2 is accurate, then achieving 425°F at 12,000 would require a fairly high thermal gradient (85°C/Km). A uniform gradient calculated over the entire depth of well 1, using the higher reported temperature, is slightly less than 65°C/Km.

The implication in the proposal is that the deeper drilling will encounter volcanic rocks similar to those at the bottom of the drilled wells. If this is true, and there are no major changes in the physical characteristics of the volcanic rocks, then such a similar gradient (65°C/Km) may continue. If, however, there is a change either in the physical characteristics of the volcanic rocks, or a different type of rock is encountered, then the thermal gradients may become isothermal or even decrease with depth. It is worth noting that Eberly and Stanley (1978, reference in RFP) interpret, on the basis of seismic data, the existence of prevolcanic rocks immediately beneath the GKI wells.

It does not seem unreasonable to expect 425°F at the projected depth, but Air Force negotiations should be based on new, reliable thermal gradient logging of the existing wells, and negotiators should be prepared for bottom-hole temperatures that could be slightly lower.

The second main geological concern is whether fractures capable of production of commercial quantities of fluid, i.e. high permeability, will be encountered. The proposal states that lack of production in existing wells is attributable to well damage and not a lack of production capability in the formation. The one million dollars will buy better completion, not a new target. The presence of fractures, and their being encountered by the drill hole, is the major gamble of this program. Both the volcanic rocks and the basement rocks could have such fractures, which, judging from experience in other geothermal systems, could still be open enough to produce commercial fluids.

A possible approach to obtain flow in the original wells would be to acidize the perforations to dissolve cement and mud damage or perform a small hydraulic fracture treatment to reach out near natural fractures beyond the damaged intervals. No analysis of well logs is given to identify where they suspect fracturing existed in those wells, nor is any consideration given to treating these old wells. Costs would be less than $100-150K.

<u>Drilling</u> - Evaluation of Geothermal Kinetics, Inc. capabilities to design and supervise the drilling of a well to 12,000+ ft in a volcanic and igneous environment is extremely difficult, as no drill plan is presented. Although the company has drilled to 13,000+ ft in the Imperial Valley, the lithlogies drilled differ. No other data are provided to suggest GKI has other geothermal drilling experience, although they are known to have drilled a minimum of three wells in the Geysers. However, the inclusion of costs of $100K for drill mud and $62K for a slotted liner and hanger suggest that construction will be similar to the existing up-hole portion of the well. "This well completion practice was typical for an oil or gas well, but unfortunately, it was not appropriate for a geothermal well..." (Geothermal Kinetics Proposal, 1981).

A detailed drilling plan should be requested of GKI. In particular, we note below a list of items that definitely require clarification.

1) It appears they will continue to employ mud in drilling deeper, even though they noted this may have created skin damage earlier. Is this a temperature-sensitive mud, is it mud-pills, or something else?

2) The mud bill appears excessive at $100K. What makes this figure so high?

3) No mention is made of rig type, or size. We seriously question the cost of Mob-Demobilization and the rig costs to drill 2800 ft of additional hole. We estimate a cost of $320K (as compared to their $570K) for these two elements. Perhaps there is something missing in these elements that additional detail would reveal.

4) How will the existing open perforations be treated in the process of drilling deeper?

5) A "barefoot" completion implies to us an "open hole" completion. However, they cost the AFB for liner and hanger. Therefore, we assume this will be determined after drilling.

6) No decision points are addressed with the AF to justify how AFB money will be spent. We would recommend these be inserted after each major work element to insure proper use of government funds.

7) All costs appear excessive. Our cost analysis is provided below.

DRILLING COST ANALYSIS

Mob-Demob	$150K
Rig 2800 ft @ 200 ft/day = 14 days	
plus 3 days testing = 17 days	
x $10000/day	170K
Fuels & Rentals	100K
Bits $7K x 5 bits	35K
Mud	40K
Slotted liner & hanger	62K
Supervision	35K
Well logs and surveys	25K
	$617K
15% Contingency	93K
Total:	$710K

Well Testing - Evaluation of the proposed well testing program is also limited by a lack of data. The recommended procedure is more typical of an oil or gas resource and may not be applicable to a fracture-controlled hydrothermal reservoir.

The recommended lancing (unloading) of the well may not cause the well to flow. The potential to flow would depend on the potentiometric surface and hydraulic characteristics of the thermal reservoir. In addition, there are no data to anticipate that a pump would not be required. Although the projected hotter temperature fluid would increase the flash-lift capabilities, no data exist to suggest a potentiometric surface is at a sufficient elevation.

The recommended short-term test with the drill rig on-site is not described and thus cannot be evaluated. However, it is unlikely that any short-term test of a fractured reservoir would assure long-term adequate production. Nonetheless, this type of test is useful and is recommended for preliminary evaluation of the well and reservoir.

Testing of the resource, after completion of the well, appears to center around development/construction of a steam/water separator. No data are presented concerning duration and discharge rates of testing. Application of short term low flowrate test data to calculate well productivity (well-bore characteristics) and reservoir kH (the ability of a reservoir to transmit fluid) are questionable for a fracture-controlled resource complicated by transient borehole density problems.

The recommendations to use downhole data to minimize transient borehole density problems and thermal borehole storage problems is commendable. However, few commercial electronic tools are available that operate in temperatures around 200°C+. Mechanical devices commonly used in the oil and gas industry do not provide sufficient precision or reliability.

The evaluation of reservoir size, hydraulic boundaries, thermal boundaries, reservoir anisotrophy, and natural thermal recharge and discharge will require additional wells. The number of required wells will depend on the complexity of the hydrogeologic environment.

The long-term flow test will provide reservoir data to establish whether the 20 acre well spacing proposed for the production wells will be adequate for the life of the project. If such spacing is not adequate, the USAF should determine how GKI will obtain adequate production.

Other geological questions center on well and reservoir characteristics. If well 2 is not capable of production, some assurances should be given to the USAF that it is capable of serving as an injection well during the long-term reservoir tests. GKI should have contingency plans if this is not the case. If the injection well needs to be worked over, the financial responsibility will have to be resolved.

Institutional and Environmental - The very brief environmental and institutional discussion included in the proposal provides little insight into potential concerns that may be associated with the drilling site/sites and the proposed development. The only information relating to environmental issues is a general statement that GKI will comply with all state and federal laws. The assertion is made that additional wells will have to be drilled and tested to make a reservoir assessment, however, no discussion of the associated impacts is presented. The only institutional information included in the proposal is the legal location description of the two existing GKI wells on Powers Ranch. This lack of discussion does not allow a reliable review of institutional and environmental issues associated with the proposed development.

Deepening the PR-1 well should have relatively little environmental impact. The well pad and reserve pit are already established and a new drilling permit is apparently not required. However, if the results of these activities are encouraging, a whole grid of an unspecified number of wells would then be established to further test the reservoir and provide energy needed to support the electrical generation plant. To evaluate the impacts that may be associated with such development, the proposer should provide a discussion that demonstrates consideration and understanding of the potential impacts. Such a discussion should inform the reviewers of the scope of development associated with the project and may identify potential subjects of concern. It is appreciated that the proposal represents only a preliminary analysis of the project and cannot be expected to provide an in-depth review of all the applicable environmental parameters. Nevertheless, a one million dollar funding request should at least provide an overview of how implementation of the proposed plan may affect the environment. At a minimum, a brief summary pertaining to the following topics should be addressed:

Location	- elaborate on where the additional well sites will be established.
Project History	- provide more information on the current status of the wells already drilled (e.g. condition of reserve pit, status of past applicable permits).
Drilling Operation	- describe the tentative plans for containment and disposal of drilling fluid and geothermal fluid produced during testing.
Site Characteristics	- summarize the physical characteristics of the proposed site and the primary environmental concerns associated with the project.
Geologic Hazards	- assess the perceived likelihood of induced seismicity or subsidence.
Water Quality	- address site considerations associated with protection of surface water and groundwater quality. Provide water chemistry analyses from PR-1 and PR-2.
Control Technology	- describe which means will be considered if the need arises to control H_2S, radon and other noncondensibel gases.
Noise	- determine if noise from the drilling operations will present a problem to neighboring activities. If so, what plans are there to minimize the disturbance.
BOPE	- describe the type of blow-out prevention equipment that will be used.
Biota Considerations	- describe any anticipated affects on terrestrial or aquatic flora and fauna; especially concerning sensitive, threatened or endangered species.
Existing Geothermal Development	- describe if there are existing geothermal develop- in the area that could be affected by the drilling, testing and use of the proposed wells,

Fluid Handling and Well Control	- describe safety precautions that will be used for handling hot geothermal fluids.
Socioeconomics	- briefly describe the demography and socioeconomics of the region and what expected impacts will result from the project.
Heritage Resources	- assess the potential of disturbing heritage resources.
Irreversible or Irretrievable Impacts	-determine if such impacts are expected as a result of the proposed development.
Regulations and Permits	- list which permits will be needed for the proposed development and present a timetable of when each of these and the project environmental evaluation will be completed.

Environmental laws will have to be strictly followed, as the water quality is likely to be poor (40,000 tds). Near surface aquifers will have to be protected.

Project Management - The review committee considered project cost, task description, work schedule and personnel in reviewing the GKI input.

The only cost identified in the proposal is for the Air Force to contribute $1,000,000 toward the project. These costs appear excessive when outlined as shown on V-II 1-4, 1-5. It would help if the costs of the project were outlined on a GSA Optional Form 60, identifying the task, who will do the work, the number of hours spent on the task, the rate per hour. Direct material, direct labor, overhead, travel, consultants, G&A expenses, royalties and profit should be identified.

The project has no work breakdown structure. The profit should be broken down into individual tasks, and the task should be outlined into statements of work, such that work activities, milestones, and deliverables can be identified. A concise and definitive Statement of Work should be provided.

There is no project or task time schedule. The project should be broken down into tasks, with start times and finish times for each activity identified.

A milestone and deliverable schedule should be included. A time requirement at each decision point necessary for review and determination to proceed should be included.

The qualifications of the project personnel are difficult to assess. For example, some of GKI's administrative personnel have impressive environmental credentials. W. Ruckelshaus (former National Director of the EPA) is Chairman of the GKI Board of Directors. The environmental head, John Bannister, was the former 15-year Director of the Arizona Oil and Gas Commission. While these individuals will probably not be directly involved with this project, their reputations and experience imply that the company would conduct its operation in an environmentally responsible manner. Resumes of Corporate officers does not enable us to evaluate the qualifications of the personnel doing the work. A planned organizational structure should be included. This structure should show the reporting relationships of key personnel and should list all key personnel who will be involved in the project. All consultants and contractors should be identified. Resumes of all participants should be provided. Relevant experience or related capabilities should be outlined.