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Methodology for Ranking Geothermal Reservoirs in Non-Electric Industrial Applications

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ABSTRACT

It is the goal of ERDA/DGE to stimulate the development of geothermal energy in the U.S. A large number of geothermal reservoirs exist and to perform a thorough study of each of these reservoirs to determine those most desirable for demonstration projects can be costly and time consuming. A methodology for assigning rankings to these reservoirs, given a limited amount of data, is presented in this paper. The top ranked reservoirs would then be studied more thoroughly. In addition, a methodology for ranking the large number of industries that could possibly utilize geothermal energy in non-electric applications is given to determine those industries which will have the most impact on national energy demand if converted to geothermal use.

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SUMMARY

One of the objectives of ERDA's geothermal energy RD&D program is to assist industry in the rapid future exploitation of the more extensive geothermal resources by facilitating near-term industrial development of identified hydrothermal resources. These identified resources may in some cases be economically used for electric generation; however, the majority of identified hydrothermal reservoirs are in the moderate temperature range, less than 90°C, where economic electric applications are not likely in the near future. For these reservoirs, and for higher temperature reservoirs where combined electric and non-electric applications are possible, reservoir development planning based on assessment of specific uses of geothermal fluid at specific sites should be initiated. Such planning is important not only to accelerate the development of specific reservoirs but also to provide the data base for effective evaluation of RD&D needs at the national level.

The concept of planning based on reservoir-specific prospectuses has been developed and presented in the MITRE Technical Report Geothermal Energy Resource Utilization Program Planning, MTR-7137, March 1976.

In implementing the concept of prospectus-oriented planning it is necessary to establish early a method of selecting reservoirs for prospectus development. A thorough study of the reservoirs to rank order them, although desirable, would be very costly and time-consuming.

The methodology presented in this paper would help provide the data needed to rank order reservoirs and would provide ERDA with the necessary information to allow informal decision making.

The acquisition of planning data has been divided into three stages. In Stage I, the set of geothermal reservoirs is examined using readily available data and rough estimating parameters, and the reservoirs are ranked according to their development potential. This Stage I study can be made quickly at the rate of approximately one or two man-days per reservoir. Following this, in Stage II, the reservoirs with the highest Stage I rankings are studied. The Stage II study is more detailed, and the main emphasis is on determining the degree of match between the site/reservoir characteristics and the requirements for both existing and new industry. As a potentially large number of industries need to be examined to determine their energy and siting characteristic requirements, a separate procedure has been developed to establish industry priorities for carrying out these analyses. Stage II studies require a good knowledge of the reservoir and its surroundings and therefore should be conducted by a regional agent familiar with the area in question. On the average it is estimated that the data acquisition for a Stage II study will require around one to two man-months per reservoir. The ranking of all the reservoirs selected for studies would take another month or two. Following the Stage II studies is the stage of prospectus development. The reservoirs ranked highest in Stage II

would be studied further and prospectuses developed for them by reservoir contractors.

The advantage of the methodology presented is that results are continuously available for decision making while the data base for such decision making is being improved. Of course, the more advanced the studies are the better the quality of these decisions.

Recommended DGE Strategy

There are certain known reservoirs which, although not ranked against all other reservoirs, have shown potential for and are in various stages of development. Moving ahead with studies and development of these reservoirs, in parallel with the process defined herein, will help accelerate overall development of non-electric applications, and in addition will provide an improved data base for this planning and evaluation procedure.

A rational strategy for DGE should thus consist of simultaneous support of both the ongoing R&D work and the data acquisition required for establishing reservoir development priorities and selecting new non-electric applications for study and RD&D. Figure 1 depicts such a strategy. The data acquisition for a Stage I study should take about five months. Following this a Stage I reservoir would be selected for study in Stage II. Work could begin early on the generation of the generic industry requirements. This work would be completed in time for the Stage II studies.

PROPOSED NEAR TERM GEOTHERMAL PROGRAM

FIGURE 1
PROPOSED ERDA/DGE NEAR-TERM PROGRAM

The site/reservoir data collection for Stage II studies could begin about seven months after the start of Stage I. Although the data are more complicated they should require less elapsed time to collect than Stage I data since reservoirs may be studied by different agents simultaneously. The data for a Stage II evaluation would become available about four months from the beginning of that effort. Stage II ranking could take one to two months including revisions to the ranking methodology. To simplify this procedure, a computer program would be prepared beforehand.

The ongoing RD&D work would continue, and could be reviewed and revised, if necessary, after each stage. The results of the ongoing work, especially the engineering and economic studies soon to be funded by DGE and the heat exchanger R&D work presently under way, should have an invaluable effect on the evaluation and scoring in the Stage II studies. A workshop could be held after completion of Stage II and prior to the beginning of prospectus development to allow ERDA/DGE to evaluate the program to date and obtain the opinion of industry on program composition and training.

SECTION 1

INTRODUCTION

GEOHERMAL RESOURCE DEVELOPMENT

One of the most important objectives of ERDA's Division of Geothermal Energy (DGE) is to stimulate the early development of a geothermal industry in such a way as to enable it to expand, as new technology becomes available, into utilization of the more expansive and difficult-to-utilize resources. In pursuit of this goal the DGE must explore many aspects of hydrothermal and geopressured reservoir development and technology applications, both electric and non-electric. This study considers specifically the non-electric aspects of utilization of the geothermal energy resource.

The mere fact of existence of a geothermal reservoir at some location in the U.S. is not sufficient to warrant its development and/or initiation of demonstrations. Many factors affect its appropriate development, and this study presents a methodology for assessing these factors in terms of the suitability of a given reservoir for development. For example, the following questions must be answered favorably for a particular reservoir to become a candidate for more detailed study:

(1) Is it technologically possible to use the heat from that particular geothermal reservoir as an energy source for a particular energy-consuming process?

(2) Is it economical to use this energy source in that process?
And if not, would the use of such energy improve the long-term

availability and reliability of the energy supply required for that process?

(3) Will there be institutional or demographic obstacles to the use of the geothermal reservoir?

A great deal of information, time, and effort are required to answer the above questions properly for all hydrothermal and geopressed reservoirs. Unfortunately, some of the needed data may not be easily obtained due to time and cost factors, or because the information is not available (for example, a method has not yet been found to reliably estimate the life of a reservoir). A complete study of a reservoir which could include a plan for reservoir development would result in a prospectus for that reservoir which would be of great value to both industry and the government. (The concept of reservoir development prospectus as a tool to stimulate resource utilization and as a basis for planning the ERDA RD&D program is discussed in the MITRE Technical Report, MTR-7137.⁽¹⁾) A prospectus study would require approximately one to two man-years to complete. The U.S. Geological Survey in their assessment of U.S. geothermal resources, Circular 726⁽²⁾ lists 66 hydrothermal reservoirs having temperatures over 150°C and more than 200 reservoirs with temperatures between 90°C and 150°C. The Circular also identifies 21 geopressured-geothermal subareas. It is true that some of the reservoirs tend to occur in clusters, and hence some of the information needed to assess their development potential may be common to all. Even then, however, the

cost of developing the required prospectuses may not be justified when one considers that some of those reservoirs are unlikely to be developed in the foreseeable future.

THREE-STAGE RESERVOIR SELECTION PROCESS

In this paper, a three-stage process (shown in Figure 1) is defined. The first two stages select specific reservoirs for prospectus development, with Stage III being the prospectus development itself. In the first two stages the reservoirs and the characteristics of the region surrounding the reservoir are tested against a limited number of selected criteria and rank ordered in terms of desirability for non-electric application development. Each succeeding stage will require more information. To illustrate: Stage I is designed to allow a quick determination of a number of characteristics of a reservoir and the area surrounding it. The information for this stage may be found in the open literature and should take on the average no more than one man-day per reservoir to collect and analyze. Based on these characteristics, a weighted score representing non-electric development potential may be given to each reservoir. The reservoirs with the highest scores may then be studied more thoroughly in Stage II. In this second stage, information on the region, demography, and more detailed information on the local industry and raw materials will be evaluated along with several institutional factors. This information may again be used to determine a Stage II weighted score for each reservoir. Existing local industry as well

FIGURE 2
THREE STAGE RESERVOIR SELECTION PROCESS

as potential new industry will be considered. The industries will be ranked according to their relative importance from a national standpoint. A preliminary methodology for this Stage II ranking is also defined in this paper. For a Stage II study, it is suggested that a regional contractor familiar with the region under study be selected to obtain the necessary information. It is expected that such a study may require one to three man-months per region to complete. The results of Stage II studies will allow more precise rank ordering of the reservoirs selected in the Stage I study. Prospectuses for the top reservoirs in the Stage II ranking may then be developed. For prospectus development, the use of a contractor familiar with the specific locale surrounding the reservoir is recommended.

METHODOLOGY

In carrying out this staged approach, it is important not to eliminate reservoirs of high development potential because of inaccuracy or unavailability of data. Thus, the Stage I procedure is designed to lean toward the positive, or higher rankings. The top-ranked reservoir will not necessarily be the best reservoir for development, but it will be one of the most promising. The methodology for ranking the reservoirs in Stages I and II of this study consists of giving a score to a reservoir according to its characteristics as compared to absolute criteria. Thus, if new information becomes available on a previously unknown reservoir, it will be possible to develop a score for this new reservoir independently of previous evaluations of other reservoirs.

Another important aspect of the methodology is that each stage may help to establish the data requirements for the next stage, such that the development of prospectuses can be made highly site-specific and hence more useful to industry and the government.

In general, it is expected that the reservoirs in Stage I will be ranked by a weighted score, which depends on:

- (1) The reservoir potential to satisfy existing industry energy demands and the size of reservoir as indication of its potential to attract new industry.
- (2) Evidence of existing geothermal development activity.
- (3) Space heating and cooling demand.
- (4) Suitability of the water resources for industrial and geothermal development.

Stage II consists of a more detailed analysis of the items above and the following additional criteria:

- (5) The feasibility of processing local raw materials using geothermal energy, and hence the potential for industrial development with the geothermal reservoir as the energy source.
- (6) The adequacy of the transportation system to support industrial expansion.
- (7) The demographic and institutional characteristics of the region including its population makeup and attitudes, its history, its infrastructure, and its rules and regulations as they affect geothermal reservoir development.
- (8) The history and attitudes of the financial institutions who may fund development projects at the reservoir.
- (9) The environment and climate of the region including the potential for the region to draw people and labor to the area.
- (10) The possible restrictions that may result from the present ownership of land.

The results of the Stage II study may be used to select reservoirs for development of prospectuses.

SECTION 2

STAGE I STUDY

SELECTION OF FACTORS

The framework for the Stage I study incorporates the following assumptions and parameters:

- (1) Limitation to 30-mile radius of a given geothermal site*.

Because the transmission range of hot brine is limited, and because of the probability that the geothermal resource extends beyond the actual drilling hole, site studies are to include all data relevant to a 30-mile radius of the known geothermal reservoir.

- (2) Use of only common factors and readily obtainable data.

Information for each factor common to all sites is needed to establish a balanced weighting system. The large number of sites and the need for efficient screening makes it necessary that data be quickly and easily obtainable.

- (3) Use of only those factors clearly related to geothermal development. Because of the rigidity inherent in a weighting system, only those factors with clearly favorable or unfavorable implications toward geothermal development should be used.

- (4) Emphasis on existing industry. Geothermal applications in existing industry are emphasized because of the immediate market potential. Consideration of geothermal applications with respect to

*Until recently, economic transport of geothermal fluid was considered to be limited to about 11 miles of the reservoir. Greater distances are now thought to be practical, and on carrying out Stage I this greater limit may need to be adjusted. This may result in greater effort required to carry out Stage I.

attracting new industry to the site is, to some extent, indicated by the degree of existing industrialization (industry attracting more industry). However, rigorous analysis of a site's propensity to attract new industry cannot be done with any validity without the detail inherent in Stage II economic and regional analysis.

To assist in establishing viable factors that could satisfy the above criteria, a preliminary data search was conducted to determine types of readily available information. The major references used in the data collection include the U. S. Geological Survey Assessment of Geothermal Resources in the United States - 1975 (Circular 726)⁽²⁾ for reservoir characteristics, as well as U. S. Bureau of the Census statistics, state manufacturers' registers, and water, commercial, and national atlases. Examples of the raw data collected may be found in Appendix Tables A-2 to A-10.

From the data collected in the preliminary search, factors were selected for application to each geothermal site. It became evident that a disparity exists between the information that could be most useful and information that is readily available. For instance, although air quality standards and information on the salinity of the geothermal resource would have been extremely useful as factors, related data are not available for all of the geothermal sites. Therefore, these factors could not be used as ranking criteria. A list of potentially relevant factors and the rationale for exclusion from this study may be found in Table 1.

TABLE 1
FACTORS CONSIDERED AND DISCARDED

<u>Factor Considered</u>	<u>Reason for Consideration</u>	<u>Reason for Discard</u>
Air Quality	To establish whether future development, including industrial or geothermal, could be banned at a given site due to air quality and other applicable state regulations.	Although the Environmental Protection Agency has required all states to formulate new state air quality standards and implementation plans, many state reports have not yet been completed or approved.
Industry Temperature Requirements	To determine whether the geothermal resource temperature would be adequate for use in a specific industry.	Detailed data on type of process would be required for each industry.
Salinity of the Geothermal Resource	To determine whether the geothermal resource could be used with a minimum of technological problems relating to salinity (includes metal corrosion, scale buildup, etc.)	Salinity data are available for only a small percentage of geothermal reservoirs.
Location of Standard Metropolitan Statistical Areas	To be used as an indication of service availability (schools, hospitals, and transportation, etc.) and the economic character of the region.	Because of the large area of many SMSAs, and the differential availability of services, it was determined that SMSA location was of limited utility.
Transmission Line and Electric Generation Plant Location	As an indication of the feasibility of adding geothermal-electric applications to the region.	Because it was decided that the factors in Stage I study should be applicable to all geothermal sites, geothermal-electric considerations are not considered. (Only high-temperature resources over 150°C, could be used for geothermal-electric.) It should be noted, however, that the optimal use of higher temperature geothermal reservoirs may be on total energy systems combining electric and non-electric applications.
Transportation Availability	As an indication of area potential for supporting new industry that could be attracted by geothermal use.	The existence of a transportation system does not assure room for expansion. Without Stage II information, it is assumed that the transportation system can support existing industry.

The following are the factors that were selected for the Stage I ranking procedure. The weighting for each factor was established through a pair-wise analysis by MITRE staff working in the geothermal field (see Appendixes B and C for details on the factor scoring and weighting). The factors and weighting are as follows:

<u>FACTORS</u>	<u>WEIGHTING</u>
A. The reservoir potential in satisfying existing industry energy demands.	33
B. Evidence of existing geothermal development activity.	28
C. Space heating demand	20
D. Suitability of water resources.	15
E. Space cooling demand	3

The following are some of the assumptions that contributed to the factor weighting decisions:

- (1) Industrial energy demands are greater and more easily facilitated by an energy source that is restricted to a given location than are residential energy demands. In addition, the presence of existing industry tends to attract new industry to a given area, thus increasing the geothermal marketing potential.
- (2) Emphasis is given to those sites where an active interest in geothermal development has already been expressed.
- (3) Geothermal space heating applications are given more emphasis than space cooling applications, due to the technological barriers of space cooling.
- (4) The availability of water is an important consideration in geothermal development. Any new industrial development would require commensurate water supplies.

PROCEDURE FOR STAGE I RANKING OF SITES

A three-step procedure has been devised to rank each of the geothermal sites for further study in Stage II. These three steps involve:

- (1) Application of all factors to each site to obtain factor scores.
- (2) Weighting of each factor score for each site.
- (3) Addition of all weighted factor scores for each site, to obtain the "total weighted factor score," which is used in the ranking of sites.

It is important to note that the specificity of this Stage I approach is quite coarse. Perturbations or changes in ranked position of specific reservoirs based on improved data or more detailed evaluation methods are to be expected. The approach is sufficient, however, to identify the candidate 50 to 75 reservoirs for Stage II studies.

In addition to using the factors for site ranking, the approach provides a first-cut indication of the upper bounds for market penetration of geothermal use. This indicator for the upper limit of industrial-geothermal potential may be obtained by totaling the energy consumption estimated for each individual industry. Assuming that the average house size for each site can be determined (a significant element in determining heating and cooling requirements), an indicator for the upper bounds for space heating and cooling applications can similarly be found. If the total amount of energy used for industry and space heating and cooling within geothermal

areas is insignificant, then it may not be useful to further pursue the study of geothermal applications at that site.

Tables A-1 to A-10 in Appendix A include data for arbitrarily chosen high-temperature geothermal reservoirs in California (see Figure A-1 for site locations). The results of Stage I application to each of these reservoirs may be found in Table 2.

As mentioned previously, the Stage I study is not of sufficient resolution to allow the conclusion that one site whose weighted factor score is slightly larger than another site has a definitely greater potential for non-electric geothermal development. However, using the sample sites in Table 2, it is evident that the Stage I methodology makes it possible to conclude that certain groups of reservoirs have more potential for geothermal development than do other groups. For instance, one may definitely conclude that Long Valley, Brawley, Heber, and East Mesa (each of which has a weighted factor score of 72 and above) have more non-electric geothermal development potential than do Border, Sespe, and Coso (which scored 28 or below). The type of geothermal development potential of each reservoir may also be construed from Table 2. For instance, factor scores indicate that Salton Sea, Brawley, Heber, and Long Valley are potential candidates for industrial geothermal use, whereas factor scores for Sespe, Long Valley, and Red's Meadow indicate potential for geothermal space heating applications.

The remainder of this section describes, in detail, the steps necessary for performing the actual ranking procedure. Included are

TABLE 2
FACTOR SCORES FOR SAMPLE SITES IN CALIFORNIA

SITE	RESERVOIR POTENTIAL IN SATISFYING EXISTING INDUSTRY ENERGY DEMAND	EVIDENCE OF EXISTING GEOTHERMAL DEVELOPMENT ACTIVITY	SPACE HEATING DEMAND	SUITABILITY OF WATER RESOURCES	SPACE COOLING DEMAND	TOTAL WEIGHTED SCORE
	WEIGHT = 33%	WEIGHT = 28%	WEIGHT = 20%	WEIGHT = 15%	WEIGHT = 3%	
Salton Sea	(1)* 33**	(1) 28	(.2) 4	(0) 0	(.8) 2.40	67.4
Brawley	(1) 33	(1) 28	(.4) 8	(0) 0	(1) 3	72.0
Heber	(1) 33	(1) 28	(.4) 8	(0) 0	(1) 3	72.0
East Mesa	(1) 33	(1) 28	(.4) 8	(0) 0	(1) 3	72.0
Border	(0) 0	(0) 0	(0) 0	(0) 0	(0) 0	0
Sespe	(.08) 2.58	(0) 0	(1) 20	(0) 0	(.4) 1.20	23.8
Coso	(0) 0	(1) 28	(0) 0	(0) 0	(0) 0	28.0
Long Valley	(1) 33	(1) 28	(1) 20	(1) 15	(0) 0	96.0
Red's Meadow	(.08) 2.58	(1) 28	(1) 20	(1) 15	(0) 0	65.6

* Factor score

** Weighted factor score

the rationale for using each factor, and the method for obtaining and weighting the factor scores. The Salton Sea, a high-temperature (over 150°C) geothermal site in California, is used to demonstrate the weighted factor scoring methodology.

WEIGHTED FACTOR SCORING METHODOLOGY

Reservoir Potential to Satisfy Existing Industry Energy Demands

This procedure indicates the potential maximum geothermal energy use for replacing existing energy sources (upper bounds based on estimate of present energy use).

Factor Scoring Procedure

Let A = an estimate of the sum of energy requirements for all industries within 30 miles of the geothermal reservoir

B = heat content of the reservoir

C = the heat content of the average hydrothermal reservoir

= 2.56×10^{18} cal (calculated from data in USGS
Circular 726⁽²⁾)

Assuming a potential for using one-fourth of the total reservoir heat content (including heat recovery and non-electric system efficiency factors) and that the reservoir will be used for a period of at least 25 years, then:

if $B > C$ $x = 1$

$B < C$ $x = \frac{B}{C}$

if $A = 0$ $y = 0$

$A \neq 0$ $y = 1$

if $100A > B$ $z = 0.5$

$100A < B$ $z = 1$

Factor score = $x.y.z$

Weighting: 33%

Salton Sea Example

A = total estimated annual fuel oil and natural gas consumption
of industries in:

Indio	716.59×10^{11}
Coachella	52.15×10^{11}
Thermal	231.99×10^{11}
Calipatria	172.11×10^{11}
Brawley	3559.02×10^{11}
Imperial	88.17×10^{11}
A =	4820.03×10^{11}

(consumption data found in Table A-4)

$B = 21 \times 10^{18}$ cal.

(reservoir data found in Table A-7)

$C = 2.56 \times 10^{18}$ cal.

since $B > C$ $x = 1$

$A \neq 0$ $y = 1$

$100A < B$ $z = 1$

Factor score = $x.y.z = 1 \times 1 \times 1 = 1$

Weighted factor score = $33 \times 1 = 33$

Evidence of Existing Geothermal Development Activity

This procedure is used to indicate present industrial interest in the geothermal site.

Factor Scoring Procedure

The factor score = 1 if either:

- (a) Geothermal utilization activities are currently taking place,
- or
- (b) If geothermal leases have been applied for.

The factor score = 0 if neither (a) nor (b) is applicable.

Weighting: 28%

Salton Sea Example

Geothermal development activity is taking place, factor score = 1

(use data found in Table A-8)

Weighted factor score = $1 \times 28 = 28$

Space Heating Demand

The amount of space heating demand is found by the following procedure:

Factor Scoring Procedure

Let A = the sum of all homes within 30 miles of the geothermal site (assuming four persons per home)

B = an indication of heating load based on degree days, whereby each range of degree days is given the following value:

<u>Heating Degree Days</u>	<u>Value of B</u>
0 - 500	0
500-1000	1
1000-2000	2
2000-3000	4
3000-4000	8
4000-5000	16
5000-6000	32
6000-7000	64
7000-8000	128
8000-9000	256
9000-10000	512
10000-above	1024

Then A x B represents space heating requirements, with higher results indicating a greater possibility for resource utilization.

Conversion of A x B to factor scores is shown as follows:

<u>A x B range</u>	<u>Factor score</u>
0-9,999	0
10,000-19,999	0.2
20,000-29,999	0.4
30,000-39,999	0.6
40,000-49,999	0.8
50,000 and above	1.0

Weighting: 20%

Salton Sea Example

Total population = 23,593 (use data found in Table A-9)

A = Total number of homes or $\frac{23,593}{4} = 5898$ homes

Heating degree days = 1000 - 2000 (use data found in Table A-9),
B = 2

A.B = 11796.5

Factor score = 0.2

Weighted factor score = $0.2 \times 20 = 4$

Suitability of Water Resources

This procedure provides an indication of whether the water resources in the vicinity of the geothermal resource could support additional industrial or geothermal development.

Factor Scoring Procedure

The geothermal sites that are in areas without indicated hydrological problems have a factor score = 1. If problems are indicated, the site score = 0.

"Problems" are defined as hydrological situations that could limit the development of new industry (such as water shortages, high salinity, or high pollution in existing water supply). It is assumed that industrial development will depend, in part, upon water availability whether or not geothermal use is to occur.

Weighting: 15%

Salton Sea Example

Because water resources in the area are high in salinity, short in supply, and with management difficulty (see Table A-10),

Factor score = 0

Weighted factor score = 1.15×0

Space Cooling Demand

This factor provides an indication of the amount of space cooling demand in the vicinity of the reservoir.

Factor Scoring Procedure

Assuming that a minimum geothermal reservoir temperature of 90°C is necessary to establish the technical feasibility of absorption cooling, the following should be applied to only those reservoirs whose temperatures exceed 90°C ,*

Let A = the sum of all homes within 30 miles of the geothermal site (assuming four persons per home)

B = the number of cooling degree days such that each range of degrees is given the following value:

<u>Cooling Degree Days</u>	<u>Value of B</u>
0-500	0
500-1000	1
1000-2000	2
2000-3000	4
3000-4000	8
4000-above	16

Then $A \times B$ represents space cooling requirements, with higher results indicating a greater possibility for resource utilization.

The conversion of $A \times B$ to factor scores shall be as follows:

* At 90°C , absorption cooling becomes technically feasible; efficiency improves with available temperatures. Using 90°C will, as with other criteria, err toward higher scores and greater likelihood of meeting the Stage II evaluation cutoff.

<u>Value of A X B</u>	<u>Factor Score</u>
below 10,000	0
10,000-20,000	0.2
20,000-30,000	0.4
30,000-40,000	0.6
40,000-50,000	0.8
50,000 and above	1

If the temperature of the geothermal reservoir $<90^{\circ}\text{C}$, then the factor score is 0.

Weighting: 3%

Salton Sea Example

Total population = 23,593 (use data found in Table A-9)

A = total number of homes of $\frac{23,593}{4} = 5898$

cooling degree days = 3000-4000 (use data found in Table A-9)
so:

B = 8

A.B = 47,184

Factor score = 0.8

Weighted factor score = $0.8 \times 3 = 2.4$

Total Weighted Score for Salton Sea

Sum of all weighted factor scores or:

	33.0
	28.0
	4.0
	0
	<u>2.4</u>
	67.4

SECTION 3

STAGE II STUDY

INTRODUCTION

Once the Stage I study is completed and the reservoirs are roughly ranked, the top-ranked reservoirs may be studied in more detail in Stage II. Additional information is acquired on the reservoir and its surroundings to permit a more accurate ranking of those reservoirs and selection of those most eligible for prospectus studies.

Whereas in the Stage I analysis the ranking is a reasonable indication of the desirability of developing a reservoir, in the Stage II study the marriage of a reservoir with particular industries is the focus. Reservoir characteristics and industry requirements are analyzed and, with these relationships established, an analytical procedure is used to assess the desirability of developing specific industry/reservoir matches. The analytical procedure developed for this purpose addresses most of the decision-making criteria likely to be used by industry; however, an additional thorough cost/benefit analysis for a specific plant would be required before an industry decides to convert to the use of geothermal energy.

The assignment of a numerical score for each criterion described in this section is a preliminary procedure which has not as yet been tested through its application to specific reservoirs. This preliminary procedure should be refined with more experience in its application.

The data have been organized in such a way as to allow easy computerization at a later time. Thus, when the procedure is refined, recomputing the scores and ranking the sites will be a simple task.

It may be advisable to conduct delphis and/or workshops at this early stage to solicit the opinions of potential users of geothermal energy as to the relative importance of the criteria included in Stage II studies.

The Stage II study will require both generic knowledge of requirements of specific industries (e.g., energy needs, temperature ranges, raw materials and feedstocks, labor, land, product markets, etc.) and extensive knowledge of the region surrounding the reservoirs under consideration. The former may be supplied by the presently conceived Engineering and Economic Studies soon to be funded by DGE. The latter may best be supplied by regional agents or regional contractors operating in and familiar with the characteristics of the geothermal reservoir areas, and with present industry in their regions, as well as with demography, natural resources, present energy supply, land use, local regulations, institutional constraints, and similar factors.

THE METHODOLOGY OF STAGE II

The methodology for Stage II is depicted in Figure 2. This methodology requires collection of extensive data regarding the region surrounding a given reservoir as well as data on existing industry in the region and industry not presently in the region but

FIGURE 3
STEPS IN STAGE II METHODOLOGY

with needs which could be satisfied in the region and which could be serviced by geothermal energy. Specific data requirements are shown in Tables 3 and 4, Table 4 applying to both existing and generic industrial descriptions. These tables are arranged in such a way as to allow anticipated future computerization and to facilitate mapping of characteristics and industrial requirements. In this tabular arrangement a given line (or row) in each table represents the similar criterion (i.e., the first row describes the geothermal resource characteristics, the second row covers the energy requirements of the applications surrounding the site). Each entry in the tables covers a unique characteristic (e.g., temperature, transportation,...). To simplify location of the characteristics in the tables, the familiar two-dimensional subscript notation has been used (e.g., the subscripts 1,2 refer to row 1 and column 2).

Table 5 explains more fully the entries to be made in Tables 3 and 4.

The site characteristics table (Table 4) is straightforward and may be assembled without any specific knowledge of geothermal applications at this reservoir.

When site-specific industry tables represent relatively new plants they should, in general, resemble the generic industry tabulations that will characterize state-of-the-art industrial practice. Differences from the generic industry are likely when existing plants are older and/or in poor repair. It may be expected, however, that

**TABLE 3
SITE CHARACTERISTICS**

RESERVOIR:

SOURCE CHARACTERISTICS	TEMPERATURE	FLOW RATE	SALINITY	PRESSURE	WELL DEPTH	EXTENT
ENERGY SUPPLY	GAS AND OIL	OTHER FUELS	POWER GENERATION AND TRANSMISSION	SUPPLY RELIABILITY	EXPANSION RATE	LOCATION
EXISTING INDUSTRY	INTERDEPENDENT INDUSTRIES	INDEPENDENT INDUSTRIES	_____	_____	_____	_____
LOCAL RAW MATERIALS	RAW MATERIAL REQUIRED FOR ABOVE	RAW MATERIALS REQUIRED FOR ABOVE	REMAINING RAW MATERIALS THAT CAN BE PROCESSED LOCALLY	_____	_____	_____
LAND USE	LAND DISTRIBUTION	LAND USE	MINERAL EXPLORATION LEASES	_____	_____	_____
CLIMATE	DEGREE-DAYS HEATING & COOLING	AVERAGE WIND DATA	AVERAGE RAIN DATA	_____	_____	_____
ENVIRONMENTAL STATUS & REGULATIONS	HYDROLOGIC PROFILE AND EFFLUENT RESTRICTION	AIR QUALITY PROFILE AND EMISSION RESTRICTION	SOLID WASTE DISPOSAL SITES	SEISMIC ACTIVITY	_____	_____
TRANSPORTATION SERVICES & CENTERS	TRANSPORTATION SYSTEM (ALL MODES)	INDUSTRIAL PRODUCTS CENTERS	COMMERCIAL PRODUCTS CENTERS	_____	_____	_____
DEMOGRAPHIC CHARACTERISTICS	NEARS POPULATION CENTER	LOCAL LABOR	LOCAL GROUPS/AGENCIES	COMMUNITY SERVICES	ATTITUDES	_____
INSTITUTIONAL CHARACTERISTICS	REGULATIONS, LAWS, STATUTES	_____	_____	_____	_____	_____
ECONOMIC CHARACTERISTICS	FINANCIAL INST.	_____	_____	_____	_____	_____

TABLE 4
INDUSTRY REQUIREMENTS

INDUSTRY:

REQUIRED GEOTHERMAL RESERVOIR CHARACTERISTICS	TEMPERATURE LIMITS	HEAT RATE REQUIRED	SALINITY LIMITS	PRESSURE LIMITS	_____	YEARLY ENERGY CONSUMPTION
ENERGY REQUIREMENTS	OIL & GAS SUBSTITUTED	OTHER FUELS SUBSTITUTED	ELECTRIC POWER REQUIRED, SAVED, OR GENERATED	SUPPLY RELIABILITY REQUIRED	YEARLY EXPANSION RATE OF ENERGY DEMAND	LOCATION OF INDUSTRY
RELATED INDUSTRIES	RELATED INDUSTRIES	_____	_____	_____	_____	_____
RAW MATERIAL REQUIREMENTS*	REQUIREMENTS	_____	REQUIREMENTS	_____	_____	_____
LAND REQUIREMENTS	LAND AGGREGATION REQUIREMENTS	LAND CLASSIFICATIONS REQUIREMENTS	MINERAL EXPLORATION LEASES REQUIRED	_____	_____	_____
CLIMATE	CLIMATE CONTROL REQUIRED	WIND LIMITS	RAIN REQUIREMENTS	_____	_____	_____
POTENTIAL ENVIRONMENTAL LIMITS	WATER POLLUTANTS	AIR POLLUTANTS	SOLID POLLUTANTS	EFFECT OF REINJECTION	_____	_____
TRANSPORTATION NEEDS	TRANSPORTATION REQUIRED	DISTANCE RESTRICTIONS ON INDUSTRIAL PRODUCTS TRANSPORTATION	DISTANCE RESTRICTIONS ON COMMERCIAL PRODUCTS TRANSPORTATION	TONNAGE	INDUSTRIAL PRODUCT MARKETS	COMMERCIAL PRODUCT MARKETS
DEMOGRAPHIC NEEDS	REQUIRED CONSUMER MARKETS	LABOR REQUIREMENTS	OBJECTIONABLE CHARACTERISTICS INTEREST GROUPS	REQUIRED COMM. SERV.	OBJECTIONABLE CHARACTERISTICS COMMUNITY	_____
INSTITUTIONAL FACTORS	CHARACTERISTICS THAT MAY CONFLICT WITH REGULATIONS	_____	_____	_____	_____	_____
ECONOMIC NEEDS	FINANCIAL SUPPORT REQUIRED	_____	_____	_____	_____	_____

* FOR ABOVE INDUSTRIES.

TABLE 5

EXPLANATION OF ENTRIES IN STAGE II TABLES

ENTRY	CHARACTERISTIC	EXPLANATION OF ENTRY IN:		
		TABLE 3	TABLE 4	TABLE 6
1,1	Temperature	Surface temperature of geothermal brine	Temperature required by process	Modifications required to temperature (e.g., heat or cool)
1,2	Flow Rate	High rated flow rate for resource	Required Heat Rate of process	Modifications required (e.g., by drilling additional wells).
1,3	Salinity	Salinity of Geothermal brine including composition of salts	Salts not acceptable by process and salinity limits	Determine whether desalinization required or secondary working fluid w/heat exchanger required
1,4	Pressure	Well pressure at surface	Pressure limits of process	Required modifications
1,5	Well Depth	Well depth	No entry	No entry
1,6	Extent	Estimated heat capacity of reservoir	Yearly energy requirements of industry	Need for augmenting non-geothermal energy

TABLE 5 (Cont'd)

ENTRY	CHARACTERISTIC	EXPLANATION OF ENTRY IN:		
		TABLE 3	TABLE 4	TABLE 6
2,1	Oil & Gas	Oil & gas consumed in region	Oil & gas which may be substituted with geothermal energy	Net decrease/increase in oil & gas consumption
2,2	Other Fuels	Other Fuels consumed in region	Other fuels which may be substituted with geothermal energy	Net decrease/increase in other fuels consumption
2,3	Power Transmission System	Capacity of present power transmission/distribution system	Electric requirements of industry and possible savings due to use of geothermal energy	Net decrease/increase in electricity consumption and its effect on the system distribution
2,4	Energy Supply Reliability	Present & projected status of supply	Reliability required by process--years of reliable supply needed to commit to establish or retrofit a plant	Net effect of the use of geothermal energy in the process
2,5	Expansion Rate	Estimated energy demand annual expansion rate for the region	Estimated energy demand annual expansion rate for process	No entry
2,6	Location	Location of geothermal resource	Present location of industry	Geothermal Fluid transmission problems expected, heat losses

TABLE 5 (Cont'd)

ENTRY	CHARACTERISTIC	EXPLANATION OF ENTRY IN:		
		TABLE 3	TABLE 4	TABLE 6
3,1	Related Industry	Industries related to each other displayed in groups	Types of industry that would be related to the industry in question (competitive as well as complementary)	Actual industries in region related to industry in question
3,2	Independent Industries	Industries which do not presently relate to others in the region	No entry	No entry
4,1	Raw Materials required for Related Industries	Major raw materials and feedstocks locally grown manufactured to support the related industry groups and the annual production of those materials	Major new materials and feedstocks required by the industry being studied	Those materials which may be used by the industry and the required modifications of local raw materials production to assure success of industry being studied
4,2	Raw Materials Required for Independent Industries	All raw materials and feedstocks locally produced to support the independent industries and the annual production of those materials	All raw materials and feedstocks required by industry if it does not belong to groups above	Same as above if industry studied is independent
4,3	Remaining Raw Materials	All raw materials and feedstocks produced locally that have potential for local processing by using geothermal energy	No entry	Same as above if industry studied will utilize those raw materials

TABLE 5 (Cont'd)

ENTRY	CHARACTERISTIC	EXPLANATION OF ENTRY IN:		
		TABLE 3	TABLE 4	TABLE 6
5,1	Land Ownership Distribution	Land ownership distribution between federal, state and private	Land requirements for industry using geothermal energy	Any major land aggregation required
5,2	Land Use	Distribution of land between recreational, residential, cropland and woodland, etc.	Land use classifications required	Any modifications in land use required
5,3	Mineral Exploration Leases	All present leases for mineral exploration	Required leases	Action required
6,1	Temperature	Degree-Days Heating Degree-Days Cooling	Any special climate control requirements	Suitability of temperature for process as well as for human comfort
6,2	Average Wind	Actual weather data on wind	Any special requirements for wind	Suitability of wind for process as well as for human comfort
6,3	Average Rain	Actual weather data on rain	Any special rain requirements	Suitability of rain for process as well as for human comfort

TABLE 5 (Cont'd)

ENTRY	CHARACTERISTIC	EXPLANATION OF ENTRY IN:		
		TABLE 3	TABLE 4	TABLE 6
7,1	Hydrologic Profile	Actual hydrologic profile and effluent restrictions	Water requirements and effluents produced	Required modifications to process output/ or hydrologic profile
7,2	Air Quality	Actual Air Quality Profile and possible restrictions	Process air emissions	Required modifications to process output/ or Air Quality
7,3	Solid Waste	Solid Waste disposal sites available	Type and Quantity of solid waste produced if any	Disposition of solid waste
7,4	Seismic Activity	Previous occurrence and severity of seismic activity in region	Estimate of effect of reinjection if contemplated otherwise estimate of effect of reservoir depletion	Recommended action to minimize possible damage to life or property
8,1	Transportation	Present transportation system serving area including land, seas, and air	Transportation requirements	Required modifications in the transportation system if any
8,2	Industrial Products Center	Proximity of industrial products market	Market distance restrictions of industry	Required action to satisfy restrictions
8,3	Commercial Products Center	Proximity of commercial Products market	Distance restrictions or product transportation	Required action to satisfy restrictions

TABLE 5 (Cont'd)

ENTRY	CHARACTERISTIC	EXPLANATION OF ENTRY IN:		
		TABLE 3	TABLE 4	TABLE 6
9,1	Population	Nearest population centers and their population	Required consumer markets	Suitability of consumer market
9,2	Labor	Local Labor, number and composition	Labor requirements profile	Sufficiency of labor
9,3	Potential Interveners	Local groups/agencies that may intervene for/ against geothermal projects	Characteristics that may give rise to objections	Possible modifications to process to make it more attractive
9,4	Community Services	Schools, libraries, etc., and their capabilities to support expansions	Required community services	Possible modifications to satisfy requirements
9,5	Attitude of Community	Resistance to change of community and its needs	Characteristics that may give rise to objections	Possible modifications to process to make it more attractive

TABLE 5 (Cont'd)

ENTRY	CHARACTERISTIC	EXPLANATION OF ENTRY IN:		
		TABLE 3	TABLE 4	TABLE 6
10,1	Regulations, Laws, Statutes	The regulations, laws and statutes covering geothermal development	Process characteri- stics that may conflict with regulations	Possible modifications to process/or regula- tions to make them compatible
11,1	Financial Institutions	Financial institutions that may be willing to invest in project	Approximate required funding	Need for government funding

TABLE 6
SITE TRANSFORMATION

RESERVOIR:

INDUSTRY:

MODIFICATION OF
GEOTHERMAL SOURCE
CHARACTERISTICS

ENERGY SUPPLY
CHANGES

INDUSTRY CHANGES

NEW LOCAL RAW
MATERIALS USED

LAND USE
MODIFICATIONS

CLIMATE
SUITABILITY

ENVIRONMENTAL
IMPACT

TRANSPORTATION
CHANGE

DEMOGRAPHIC
SUITABILITY

INSTITUTIONAL
CHANGE

ECONOMIC
SUITABILITY

HEAT COOL	PUMP THROTTLE	DESALINIZE O.K.	PRESSURIZE EXPAND (FLASH)	—	—
AS IS DECREASE	AS IS DECREASE OTHER FUELS	AS IS MODIFY	RELIABILITY INCREASED/DECREASED	—	GEOTHERMAL FLUID TRANSMISSION
RELATED IDUST. REQUIRED	—	—	—	—	—
EXPAND PRODUCTION OK AS IS	EXPAND PRODUCTION OK AS IS	EXPAND PRODUCTION OK AS IS	—	—	—
MODIFY OK AS IS	MODIFY OK AS IS	ACTION REQUIRED	—	—	—
SUITABILITY	SUITABILITY	SUITABILITY	—	—	—
MODIFICATIONS	MODIFICATIONS	DISPOSITION OF SOL. POLL.	ACTION REQUIRED TO MINIMIZE DAMAGE	—	—
EXPAND OK AS IS	REQUIRED ACTION	REQUIRED ACTION	—	—	—
SUITABILITY OF CONSUMER MARKET	SUFFICIENCY OF LOCAL LABOR	POSSIBLE MODIFICATIONS TO PROCESS	POSSIBLE MODIFICATIONS TO PROCESS	POSSIBLE MODIFICATIONS TO PROCESS	—
POSSIBLE MODIFICATIONS TO PROCESS/REGULATIONS	—	—	—	—	—
GOVT. SPT. REQUIRED OK AS IS	—	—	—	—	—

the site-specific industry information may be obtained from the generic industry information with slight modifications.

Once both sets of data are developed, the next step is to analyze the Table 3 site characteristics in light of the Table 4 industry requirements. In general, it is expected that differences will be observed: the site characteristics will not meet all of the industrial requirements.* These differences will yield a new set of site/reservoir deficiency data. These data may similarly be arranged in tabular form of the same dimension and element location as Tables 3 and 4 (see Table 6, Site Transformation Table). The elements of the latter, if applied to the site characteristics table, should transform it to satisfy the specific industrial requirements being analyzed. The entries in Table 6 have also been defined in more detail in Table 5.

Using these three descriptive tabulations (Tables 3, 4 and 6) an evaluation scheme which assesses the potential for retrofitting existing industry, and for attracting new industry, may be developed and exercised. Appendix B presents a preliminary scoring method for use with the above-described data. The method presented therein has not yet been tested with actual site and industrial requirement data, as the latter have not been available. It is likely that the

*It should be noted that several of the entries in the site characteristics table do not have comparable entries in the industrial requirements table. These site description factors represent general regional attributes which may enhance or retard geothermal development. The scoring procedure discussed in Appendix B deals with these factors directly rather than through this industrial requirements comparison procedure.

preliminary method presented in Appendix B will be refined as it is put into application; however, it is also expected that the basis of the method--first-order linear combination of objective functions--will remain a useful paradigm.

SECTION 4

METHODOLOGY FOR RANKING OF INDUSTRIES

There are a large number of industrial processes that may be converted to the use of geothermal energy. A screening method to rank order these industries in non-electric applications is presented in this section. The basis for the ranking is the impact that conversion to geothermal use of those industries will have on national energy demand. A score is given to each industry based on relative energy consumption of the industry, its present size in states possessing geothermal resources, and the amount of geothermal energy that state possesses. (As near-term payoff is being emphasized in this paper, the resource data used are limited to hydrothermal.)

The score is then given by:

$$\text{Score for industry } j = \sum \frac{\text{Annual energy consumed in industry } j}{\text{Total U.S. industrial energy consumption All states}} \times 100$$

$$\times \frac{\text{Size of industry } j \text{ in state } i}{\text{Total U.S. size of industry } j} \times 100$$

$$\times \frac{\text{Size of geothermal reserves in state } i}{\text{Total U.S. geothermal reserves}} \times 100$$

Discussion of Industry Ranking

The factors selected for the generation of a score for each industry are a gross indication of the upper bound of geothermal energy use by a given industry.

Energy Consumption of the Industry. If the energy requirements of the industry are small, then even if all the establishments of that type are converted to geothermal energy use in the U. S., the effect on energy consumption would be negligible. As with the Stage I screening method, this procedure will err toward higher scores in that it makes no allowance for those cases in which the energy requirements of the industry may not be fulfilled by the low-temperature heat that is characteristic of many geothermal resources. To improve this situation, after rank ordering industries using this method, additional screening information may be obtained from the few industry engineering studies which have already been carried out.

Relative Size of Industry in a State. Inherent in the use of this factor is the assumption that gross industry redistributions will not occur. It is not expected that the applicability of geothermal energy to certain processes will have a large impact on the distribution of industries in the U. S., at least not in the near future. If shifts of industry to states with geothermal reserves can be forecast, then a more appropriate factor in this case would be based on the projected size of the industry in the state as a percentage of the national size of that industry.

Relative Size of Geothermal Reserves in the State. Inherent in this factor is the assumption that the present assessment of U. S. hydrothermal reserves⁽²⁾ is reasonably accurate and that relative distribution among the states will not change drastically.

As mentioned above, this paper considers only hydrothermal reserves. But as the technology for the use of other types of geothermal resources (such as geopressured and hot dry rock) becomes available, this factor will change greatly.

Finally, in the generation of the scores the ranking was assumed to depend on the first power of the three factors discussed above. However, as some of the data become available, it may be necessary to alter this scoring procedure to redistribute the emphasis among those factors.

Example of Industry Ranking

To illustrate the procedure, ratings are performed for some of the industries that may be converted to geothermal energy, according to presently available studies. To facilitate data gathering, the classifications chosen are quite broad; however, the trends shown do point to possibilities for future studies. The industries are listed in Table 7 together with their SIC⁽³⁾ codes. Industries with two-digit SIC codes are listed with others having three-digit SIC codes. The energy consumption of these industries and its percent of total U. S. industrial energy consumption is shown for each industry in the table. In Table 8, the distribution of hydrothermal reserves by state in the temperature range of 90° to 150°C (the range usually considered for non-electric applications) is shown. In case of these reserves, the reservoir size is usually between 0.2×10^{18} and 10×10^{18} calories. However, there are two reservoirs, one with estimated heat content of 263×10^{18}

TABLE 7

TOTAL U. S. ENERGY CONSUMPTION OF SELECTED INDUSTRIES

INDUSTRY TYPE AND SIC CODE	ENERGY CONSUMPTION IN 10 ⁹ KW HR	PERCENT OF TOTAL U.S. INDUSTRIAL ENERGY CONSUMPTION
Canned, Cured & Frozen Foods 205	38.7	1.0
Sugar 206	38.7	1.0
All Other Food and Kindred Products 20 - (203+206)	223.2	5.8
Paper & Allied Products 26	385.4	10.0
Industrial Chemicals 281	579.2	15.06
Soap 284	15.6	.4
Agricultural Chemicals 287	24.0	.62
All Other Chemicals & Allied Products 28 - (281+284-287)	195.4	5.08
Petroleum & Coal Products 29	466.9	12.14

TABLE 8
HYDROTHERMAL ENERGY DISTRIBUTION BY STATE
FOR 90 - 150°C TEMPERATURE RESERVOIRS

STATE	ESTIMATED ENERGY CONTENT IN UNITS OF 10^{18} CAL ⁽²⁾	PERCENT
Alaska	4.7	9.1
Arizona	1.0	1.9
California	12.0	23.3
Colorado	2.9	5.6
Hawaii	1.0	1.9
Idaho	276.2	25.6 (535.3)*
Montana	1.6	3.1
Nevada	8.5	16.5
New Mexico	.8	1.5
Oregon	33.4	6.6 (64.7)*
Utah	1.2	2.3
Washington	.9	1.7
Wyoming	.4	.8

344.6×10^{18} cal

Less* (263 + 30) -293

51.6×10^{18} cal

* Single reservoirs with heat contents of 263×10^{18} cal and 30×10^{18} exist in Idaho and Oregon respectively. These were excluded from the calculation of the percentages for all states. They were reintroduced in the calculation of percentage for Idaho and Oregon only (numbers in parentheses).

calories in Bruneau-Grandview, Idaho, and one with an estimated content of 30×10^{18} calories in Klamath Falls, Oregon. Because of the unusual size of these reservoirs and the bias they will create in the data if included in the percentage calculations, they have been omitted from the calculation. If included, the percentages for Idaho and Oregon would be those shown in the parenthesis.

For the relative size of the industry in a state, the only data that could be found easily were those in the 1972 Census of Manufacturers⁽³⁾. The employment figures contained therein were used to obtain the relative size of the industry. The resulting products of the three factors for each state and industry are shown in Table 9. The sum of these products across each row gives a total score for that industry. This score, together with a normalized index of importance, is shown in the last two columns of the table. When the two large reservoirs are included the index is as shown in Table 10.

Tables 9 and 10 indicate that the chemical industries should receive the highest attention while soap and agricultural chemical industries appear to be of least importance. Pulp and paper industries also rank high in importance .

The above conclusions are based on only partial data. As studies progress and as more information is collected it is quite possible that other industries will emerge as leaders for consideration.

TABLE 9
RELATIVE IMPORTANCE OF SELECTED INDUSTRIES IN STATES WITH GEOTHERMAL RESERVOIRS

INDUSTRY & SIC CODE	ALASKA	ARIZONA	CALIFORNIA	COLORADO	HAWAII	IDAHO	MONTANA	NEVADA	NEW MEXICO	OREGON	UTAH	WASHINGTON	WYOMING	RELATIVE IMPORTANCE	
														SUM	INDEX
Canned, Cured & Frozen Foods (205)	0	.3	501	2.4	4.	25.6 (535.3)	0	2.64	0	25.7 (252.3)	.3	6.26	0	568.2 (1,304)	16.5 (8.2)
Sugar (206)	0	.34	223	13	6.72	41.7 (872)	1.08	0	0	4.6 (45.3)	1.72	2.21	.28	294.65 (1,165)	8.6 (7.3)
All Other Food & Kindred Products 20-(203+206)	0	5.51	1,039	47.73	.55	16 (334)	4.52	7.66	2.73	37.5 (368)	6.38	13.51	.29	1,181.38 (1,830)	34.3 (11.5)
Paper & Allied Products (26)	24.6	2.7	1,258	16.8	.6	.99 (20.8)	1.9	0	0	89. (873)	1.4	46.2	0	1,463 (2,246)	42.5 (14.1)
Industrial Chemicals (281)	0	5.7	1,084	16.9	0	678 (14,186)	9.33	124	4.5	37.7 (370)	6.9	97.3	0	2064.33 (15,904)	60 (100)
Soap Products (284)		.1	90.4	.4	.14	0	0	0	0	0	.16	0	0	91.2 (.6)	2.65 (.6)
Agricultural Chemicals (287)	0	.47	93	2.7	0	24.77 (518)	0	0	0	0	0	.66	0	121.6 (614.8)	3.53 (3.9)
All Other Chemical Industries 28-(281+284+287)	0	4.62	571.70	5.38	.3	6.5 (135.99)	.46	4.22	.25	9.38 (92.05)	1.98	2.44	0	606.93 (819)	17.65 (5.15)
Petroleum & Coal Products (29)	0	6.2	3,266	38.7	6.2	0	20.3	0	3.76	42.3 (415)	15.78	31	8.98	3439.22 (3,812)	100 (24)

TABLE 10

COMPARISON OF INDUSTRY INDEX WITH AND WITHOUT INCLUSION OF
THE TWO LARGE HYDROTHERMAL RESERVOIRS IN IDAHO AND OREGON

INDUSTRY & SIC CODE	INDEX EXCLUDING TWO LARGE RESERVOIRS	INDEX INCLUDING TWO LARGE RESERVOIRS
Canned, Cured & Frozen Foods 205	16.5	8.2
Sugar 206	8.6	7.3
All other Food and Kindred Products 20 - (203+206)	34.3	11.5
Paper & Allied Products 26	42.5	14.1
Industrial Chemicals 281	60	100
Soap 284	2.65	.6
Agricultural Chemicals 287	3.53	3.9
All Other Chemicals & Allied Products 28 - (281+284-287)	17.65	5.15
Petroleum & Coal Products 29	100	24

As for the scores for Idaho and Oregon, it is important to determine the proximity of the industries to the large reservoirs. If it is found that all industries will be located adjacent to those reservoirs, then the larger percentages should be used.

APPENDIX A

STAGE I RAW DATA

Appendix A provides supplementary information for the Stage I geothermal site ranking methodology described in Section 2. Included in Appendix A are raw data collected in the preliminary data search for the sample sites indicated in Figure A-1. This information was primarily intended to determine what data are available for use in determining factors for the ranking of geothermal sites. Once the factors were chosen, the information used in ranking calculations was a subset of the raw data tables.

A list of Stage I factors that were finally derived and the raw data applied to each factor are summarized in Table A-1. Tables A-2 to A-10 contain all the data collected for this study. In the future, ranking of additional geothermal sites would be more time-efficient if only Table A-1 data are collected.

- Key
- A Salton Sea
 - B Brawley
 - C Heber
 - D Border
 - E East Mesa
 - F Sespe
 - G Coso H.S.
 - H Red's Meadow
 - I Long Valley

FIGURE A-1
CALIFORNIA STUDY SITES

TABLE A-1

FACTORS CHOSEN AND RELEVANT DATA FROM RAW DATA TABLES

<u>Factor</u>	<u>Table</u>	<u>Data from Table, Applied to Factor</u>
A. Reservoir Potential in Satisfying Existing Industry Energy Demands	A-4 A-7	Total Estimated Industrial Fuel Oil and Natural Gas Consumption by City or Town Reservoir Assumptions: Heat Content
B. Evidence of Existing Geothermal Development Activity	A-8	Energy and Utilities
C. Space Heating Demand	A-9	Population and Heating Degree Days
D. Suitability of Water Resources	A-10	Water Resources
E. Space Cooling Demand	A-9	Population and Cooling Degree Days

TABLE A-2
LAND USE

	GENERAL DESCRIPTION	PUBLICLY OWNED LAND	CROPLAND	FOREST AND WOODLAND	TRANSPORTATION
Salton Sea	Desert shrubland mostly ungrazed E. and SW of Sea. Irrigated N.W. and S.E. Desert shrubland grazed to west. Salton Sea: primarily recreation area, many water sports.	El Centro Naval Facility E. of Sea. National Wildlife S. of Sea. Scattered Federally owned tracts 25-50% density and 50-100% density.	1964: 15.0-29.9% of land in Imperial Co. as cropland. Riverside and San Diego Counties 5.0-14.9%. NW of Sea: fruit & nut farms, particularly grapes & grapefruit. Some cotton. SE of Sea: cotton, barley, sorghum, sugar beets, tomatoes, some flax and watermelon.	Imperial Co: 0-4.9% forest and woodland. Riverside & San Diego Co. 5.0-14.9%. Nothing in close proximity to the Sea.	Coachella Canal E. of Sea. Southern Pacific RR E. and S. of Sea.
Brawley, Heber, Border, East Mesa	Irrigated land. Imperial Co.	See Above	See "SE of Sea" above	See "Imperial Co." above. No forest or woodland in immediate area.	Southern Pacific RR with "Freight Only" stops at Brawley and Heber. State Highways 86, 78, 111, 115. Interstate 8. All American canal.
Sespe, H.S.	Predominantly forest and woodland. In center of Ventura Co. which is $\approx$ 50% National Forest.	Los Padres National Forest, Angeles National Forest in area.	Ventura Co.: 5-14.9% cropland. No outstanding crop in area (primarily livestock and dairy).	More than 75% of county is forest & woodland, 15-29.9% of land for grazing.	Southern Pacific RR, freight only.
Coso H.S.	In Inyo Co., $\approx$ 15 mi S. of Owens Lake, 2 mi E. of Tulare Co. line. Predominantly forest & woodland, mostly ungrazed. Desert shrubland grazed to E. No population.	Inyo National Forest, Sequoia National Forest & Park W. of Coso. Haiwee Reservoir N., Death Valley National Monument E., Naval Ordinance Test Station S.	Inyo Co: 4.9% and under for cropland. Tulare Co: 15-29.9%. No predominant crops in Coso area.	4% and under, forest & woodland in Inyo Co. 50-74.9% in Tulare Co.	Southern Pacific RR, Freight only. Los Angeles Aqueduct in area.
Red's Meadow	At Mono/Madera county lines, near Fresno Co. In Inyo National Forest	In Inyo National Forest adjacent to Sierra National Forest.	No significant crops in area.	Forest and Woodland (all National)	
Long Valley	Mono Co., at Lake Crowley, Surrounded by Inyo National Forest. Approximately 10 mi E. of Red's Meadow	See "Red's Meadow," above	See "Red's Meadow," above		

**TABLE A-3
BUSINESS AND INDUSTRY
(by City and Town)**

	BUSINESS CENTERS (WITHIN 60 MILES) ⁽⁵⁾	INDUSTRY (WITHIN 30 STRAIGHT-LINE MILES OF GEOTHERMAL SITE BY CITY OR TOWN LOCATION - DISTANCES ARE APPROXIMATE) ⁽⁶⁾
Salton Sea	El Centro: County Seat Callexico: basic retail- ing	<p><u>Indio:</u> 17 mi NW of Salton Sea California Date Growers Assoc.: dates and date products. Employs 400. Sales group C.* 2034**</p> <p>Coachella Valley Ice Co.: Ice. Employs 24. Sales G 2097</p> <p>Daily News: newspaper publishing. Employs 66. 2711</p> <p>Imperial Valley Sign Co., Div. of Western Electric Advertising, Inc.; neon plastic displays, billboard displays, aluminum extrusion signs, sign painting. Branch office. Total employees 30, sales E. 3993</p> <p>Massey Sand and Rock Co.: paving rock and sand, ready-mix con- crete. Main office & plant. Total employees 240, total sales C 3272</p> <p><u>Coachella:</u> 15 mi NW of Salton Sea Anderson's Lee Covalda Date Co: dates, date products and con- fections. Employs 20. Sales F. 2034</p> <p>Coachella Valley Sun: Weekly, monthly publications. Employs 5. Sales G. 2711</p> <p>Co-Val Concrete Pipe Co.: concrete pipe, irrigation and drainage system installed. Employs 35. 3272</p> <p>C-V Concrete Products: concrete products. Employs 15. Sales G. 3272</p> <p>Penzoil Co. (Western Div.): automotive & industrial lubricating oils and grease. 2992</p> <p><u>Thermal:</u> 10 mi NW of Salton Sea California Redi-Date Co.: growers, packers and shippers of dates and date products. Employs 150. Sales D. 2034</p> <p>Desert Box and Supply Corp.: produce boxes, baskets, stakes and shippers' supplies, chain saws and service outboard motors and service. Employs 20 (seasonally). Sales D. 2441</p>

TABLE A-3 (CONTINUED)

	BUSINESS CENTERS (WITHIN 60 MILES)	INDUSTRY (WITHIN 30 STRAIGHT-LINE MILES OF GEOTHERMAL SITE BY CITY OR TOWN LOCATION - DISTANCES ARE APPROXIMATE)
Salton Sea (Cont'd)		<p><u>Calipatria:</u> 7 mi SE of Salton Sea. Hydro Conduit Corp.: concrete pipe, prestressed structural products. Branch plant. Total 404. Sales A. 3272 Producers Cotton Oil Co.: cotton, cotton ginning, cotton seed products, agricultural commodities, land management. Branch offices. 2091</p> <p><u>Brawley:</u> 15 mi SE of Salton Sea. See "Brawley" below.</p> <p><u>Imperial:</u> 25 mi SE of Salton Sea. See "Brawley" below.</p>
Brawley	See "Salton Sea", above	<p><u>Brawley:</u> at geothermal site. Holly Sugar Corp.: sugar. Branch plant. Total** employees 2500. Sales A. Brawley employees 250. 2062 Peterson Manufacturing Co., Inc.: tallow. Branch plant. Total employees 275. Sales B. 2094 Westerland Box Co.: wooden boxes, crates, excelsior, shippers' supplies. Branch plant. Total employees 30. Sales C. 2441</p> <p><u>Calipatria:</u> 12 mi N. of Brawley. See "Salton Sea", above.</p> <p><u>Imperial:</u> 10 mi S. of Brawley Calcot compress: compression and storage of raw cotton. Branch plant. Total employees 175, sales G. 3522 Chem. Fab. Corporation: chemical milling process. Employs 30. 3599</p> <p><u>El Centro:</u> 12 mi S. of Brawley. See "Heber" below.</p>

TABLE A-3 (CONTINUED)

	BUSINESS CENTERS (WITHIN 60 MILES)	INDUSTRY (WITHIN 30 STRAIGHT-LINE MILES OF GEOTHERMAL SITE BY CITY OR TOWN LOCATION - DISTANCES ARE APPROXIMATE)
Heber	See "Salton Sea", above	<p><u>El Centro</u>: 5 mi N. of Heber.</p> <p>Ferry-Morse Seed Co.: seeds. Branch plant. Total employees 500, sales B. 0181</p> <p>Imperial Valley Press: newspaper printing and publishing. Employs 83. Sales D. 2711</p> <p>Imperial Valley Sign Co., Div. of Western Electrical Advertising, Inc.: Main office and plant. See "Imperial Valley Sign Co., Salton Sea", above.</p> <p>Ryerson Concrete, Inc.: Concrete products, transit mix, ditch-lining. Employs 50. Sales D. 3270</p> <p><u>Imperial</u>: 7 mi N. of Heber. See "Imperial", above.</p> <p><u>Calxico</u>: 5 mi S. of Heber</p> <p>Calxico Chronical: newspaper publishing and commercial printing. Employs 6. Sales G. 2711</p> <p>Western Gear de Mexico, Div. of Western Gear Corp.: electro-mechanical products. Total sales A. 3621</p>
East Mesa and Border	See "Salton Sea,"above	<p><u>Brawley</u>: 25 mi NW of E. Mesa. See "Brawley," above</p> <p><u>Imperial</u>: 20 mi NW of E. Mesa, 27 mi. NW of Border. See "Imperial," above.</p> <p><u>El Centro</u>: 17 mi W. of E. Mesa, 25 mi. NW of Border.</p>

TABLE A-3 (CONTINUED)

	BUSINESS CENTERS (WITHIN 60 MILES)	INDUSTRY (WITHIN 30 STRAIGHT-LINE MILES OF GEOTHERMAL SITE BY CITY OR TOWN LOCATION - DISTANCES ARE APPROXIMATE)
Sespe H.S.	Los Angeles, regional and national retail center. Santa Barbara, Ventura retail centers. Bakersfield regional retail center. Oxnard: retail, some manu- facture.	<p><u>Fillmore</u>: 3 mi E. of Sespe. Corl & Fleming, Inc.: farm machinery and equipment. Employs 15. Sales G. 3522 Fillmore Herald: publishing, printing. Employs 5. Sales G. 2711 Hoyle Engineering Co.: Drafting instruments. Employs 5. Sales G. 3811</p> <p><u>Santa Paula</u>: 8 mi SW of Sespe. Associated Concrete Products Inc.: Precast concrete vaults, sewer manholes, crypts, meter boxes. Branch Plant. Total employees 400, Sales B. 3272 Calavo Growers of California: Avacados, dried package fruits. Branch Plant. Total employees 300. Sales A. 0715 Golden Manufacturing Corp.: Sporting goods (golf training device and rope tighteners). Employs 7. Sales G. 3949 Livingston - Graham: concrete ready-mix, rock, sand, gravel. Branch Plant. Total employees 610. 3272 Prescon Corp.: concrete products (prestressed units for concrete construction). Employs 50. Sales D. 3270 Santa Paula Daily Chronicle: daily newspaper. Employs 41. Sales E. 2711 Weyerhaeuser Company: corrugated and solid fibre boxes. Employs 150. Sales B. 2432</p>

TABLE A-3 (CONTINUED)

	BUSINESS CENTERS (WITHIN 60 MILES)	INDUSTRY (WITHIN 30 STRAIGHT-LINE MILES OF GEOTHERMAL SITE BY CITY OR TOWN LOCATION - DISTANCES ARE APPROXIMATE)
Sespe H.S. (Cont'd)		<p><u>Simi Valley</u>: 12 mi SE of Sespe. Benedict Lust Publications: publishing, magazines and books. Employs 6. Sales F. 2721</p> <p>Free Drop Top Inc.: plastic products, plastic janatorial maintenance equipment, custom rotational molding. Employs 47. Sales 3. 3079</p> <p>Hammond Dental Mfg. Co.: dental alloys and mercury. Employs 3. Sales G. 3843</p> <p><u>Ojai</u>: 20 mi W. of Sespe. Ojai Industrial Tools, Inc.: Thin solid carbide saws, jigs, fixtures, tooling. Employs 40. Sales D. 3544</p> <p>Ojai Valley News: publishing and printing (newspaper). Employs 16. Sales F. 2711</p> <p><u>Camarillo</u>: 15 mi S. of Sespe. Camarillo Daily News: newspaper publishing. Employs 50. Dales E. 2711</p> <p>Clifford Industries Inc.: power supplies, inverters, stereo speaker switches, windshield wiper programmer, headlight shut off. Employs 18. Sales E. 3679</p> <p>Custom Electronic Design: electronic equipment and test equipment. Employs 10. Sales G. 3674</p> <p>Minnesota Mining and Manufacturing Co., Data Recording Products Div.: recording instruments and equipment. Division total employees 650. Sales A. 3679</p>

TABLE A-3 (CONTINUED)

	BUSINESS CENTERS (WITHIN 60 MILES)	INDUSTRY (WITHIN 30 STRAIGHT-LINE MILES OF GEOTHERMAL SITE BY CITY OR TOWN LOCATION - DISTANCES ARE APPROXIMATE)
Sespe H.S. (Cont'd)		<p>Hawley L.S. Corp.: quarry (rock rip rap, filter rock, road base). Employs 25. Sales D. 1429</p> <p>Monier - Raymond Concrete Tile Co.: concrete roof tile. Branch Plant. Total employs 250. Sales B. 3271</p> <p><u>Thousand Oaks</u>: 20 mi S. of Sespe. Cathy Accessories Inc.: clothing. Employs 125. 2396</p> <p>Scripps, John P. Newspapers: newspaper publishing and printing. Branch Plant. Total employees 800. Imports. 2711</p>
Coso H.S.	<p>Bakersfield: regional retail center.</p> <p>Porterville: retail- ing business center</p>	
Red's Meadow	<p>Fresno: retailing regional center. Manufacturing Center.</p>	
Long Valley	See "Red's Meadow", above.	<p><u>Mammoth Lakes</u>: 10-15 mi NW of Long Valley. Haddaway Mfg. L tuned vibrator air pump for invest- ments, aeration. Employs 6. 3561</p>

* Annual Gross Sales Code. Sales A = over \$25,000,000; Sales B = \$10-25,000,000; Sales C = \$5-10,000,000;
Sales D = \$1-5,000,000; Sales E = \$500,000-1,000,000; Sales F = \$250,000,000; Sales G = Less than \$250,000.

** U.S. Bureau of the Census, Standard Industrial Code number.

*** "Total" Employees and Sales represents the sum of all branch offices and plants.

MANUFACTURER (6)

STANDARD
INDUSTRIAL
CODE (SIC)(6)

**A. INDIVIDUAL
MANUFACTURER
EMPLOYMENT(6)**

B. NATIONAL TOTAL
EMPLOYMENT BY
SIC GROUP 10^3 (3)
(1000) = 10³ (3)

C. NATIONAL TOTAL
FUEL OIL CONSUMPTION
BY SIC CODE (7)
(1000 BARRELS)

D. FUEL OIL CAL.
EQUIVALENT
1 BARREL = 1.46×10^9 CAL.)

**E. NATIONAL TOTAL NATURAL
GAS CONSUMPTION BY SIC
(BILLION FT³)(7)**

F. NATURAL GAS EQUIVALENT,
(1 CU. FT. = 2.60×10^5 CAL.)

G. COMBINED FUEL OIL
AND NATURAL GAS
D + F

H. COMBINED FUEL OIL
AND NATURAL GAS ENERGY
CONSUMPTION OF INDIVIDUAL
MANUFACTURER A x C

1. TOTAL ESTIMATED INDUSTRIAL FUEL OIL AND NATURAL GAS CONSUMPTION BY CITY OR TOWN

SALTON SEA: Indio	Calif. Date Growers	2034 Dehydrated Food Products	400	12.4	101.0	1.47×10^{14}	6.7	17.42×10^{14}	18.89×10^{14}	609.5×10^{11}	716.59 $\times 10^{11}$
	Coachella Valley Ice Co.	2097 Manufacturing Ice	24	6.8	(S)*	(S)*	(S)*	(S)*	(S)*	(S)*	
	Daily News	2711 Newspapers	66	348.5	261.2	3.81×10^{14}	8.4	21.84×10^{14}	25.65×10^{14}	4.86×10^{11}	
	Imperial Valley Sign Co.	3993 Signs & Advertising Displays	30 T**	49.8	(S)*	(S)*	(S)*	(S)*	(S)*	(S)*	
	Massey Land and Rock Co.	3272 Concrete Products, n.e.c.***	240 T**	67.7	746.6	10.90×10^{14}	6.9	17.94×10^{14}	28.84×10^{14}	102.24×10^{11}	
	Anderson's Lee Covalda Dates	2034 Dehydrated Food Products	20	12.4	101.0	1.47×10^{14}	6.7	17.42×10^{14}	18.89×10^{14}	30.48×10^{11}	
	Coachella Valley Sun	2711 Newspapers	5	348.5	261.2	3.81×10^{14}	8.4	21.84×10^{14}	25.65×10^{14}	$.37 \times 10^{11}$	
	Co-Val Concrete Pipe Co.	3272 Concrete Products, n.e.c.***	35	67.7	746.6	10.90×10^{14}	6.9	17.94×10^{14}	28.84×10^{14}	14.91×10^{11}	
	C-V Concrete Products	3272 Concrete Products, n.e.c.***	15	67.7	746.6	10.90×10^{14}	6.9	17.94×10^{14}	28.84×10^{14}	6.39×10^{11}	
	Fennott Co. (Western Div.)	2992 Lubricating Oils and Greases	—	8.1	170.9	—	1.6	—	—	—	
Thermal	Calif. Radi-Date Co.	2034 Dehydrated Food Products	150	12.4	101.0	1.47×10^{14}	6.7	17.42×10^{14}	18.89×10^{14}	228.56×10^{11}	231.99 $\times 10^{11}$
	Desert Box and Supply Corp.	2441 Nailed Wooden Boxes and Shook	20	10.7	36.8	$.54 \times 10^{14}$	.5	1.30×10^{14}	1.84×10^{14}	3.43×10^{11}	
Calipatria	Hydro Conduit Corp.	3272 Concrete Products, n.e.c.***	404 T**	67.7	746.6	10.90×10^{14}	6.9	17.94×10^{14}	28.84×10^{14}	172.11×10^{11}	172.11 $\times 10^{11}$
	Producers Cotton	2091 Cottonseed Oil Mills	—	16.0	14.7	—	3.8	—	—	—	
	(See "Brawley" and "Imperial," Below)										
BRAWLEY	Holly Sugar Corp.	2062 Cane Sugar Refining	250	10.9	1,439.4	21.02×10^{14}	23.1	60.06×10^{14}	81.08×10^{14}	$1,859.52 \times 10^{11}$	3,559.02 $\times 10^{11}$
	Peterson Manufacturing Co.	2094 Animal and Marine Fats and Oils	275	11.6	1,298.0	18.95×10^{14}	20.2	52.52×10^{14}	71.47×10^{14}	$1,694.35 \times 10^{11}$	
	Westerlund Box Co.	2441 Nailed Wooden Boxes and Shook	30	10.7	36.8	$.54 \times 10^{14}$	.5	1.30×10^{14}	1.84×10^{14}	5.15×10^{11}	
Imperial	(See "Calipatria," Above)										88.17 $\times 10^{11}$
	Calcot Compress	3523 Farm Machinery	175 T**	104.6	299.7	4.38×10^{14}	17.4	45.24×10^{14}	49.62×10^{14}	83.01×10^{11}	
	Chem. Fab. Corporation	3599 Misc. Machinery, Except Electrical	30	157.8	274.1	4.00×10^{14}	8.9	23.14×10^{14}	27.14×10^{14}	5.16×10^{11}	
(See "El Centro," Below)											
HEBER: El Centro	Imperial Valley Press	2711 Newspapers	83	348.5	261.2	3.81×10^{14}	8.4	21.84×10^{14}	25.65×10^{14}	6.11×10^{11}	39.81 $\times 10^{11}$
	Imperial Valley Sign Co.	3993 Signs and Advertising Displays	30 T**	49.8	(S)*	(S)*	(S)*	(S)*	(S)*	(S)*	
	Ryerson Concrete Co., Inc.	3270 Concrete, Gypsum, Plaster Products	50	193.1	6,897.3	100.70×10^{14}	85.6	222.56×10^{14}	323.26×10^{14}	83.70×10^{11}	
	(See "Imperial," Above)										

TABLE A-4 (CONCLUDED)

SITE	MANUFACTURER	STANDARD INDUSTRIAL CODE (SIC)	A. INDIVIDUAL MANUFACTURER EMPLOYMENT	B. NATIONAL TOTAL EMPLOYMENT BY SIC GROUP (1000 = 10 ³)	C. NATIONAL TOTAL FUEL OIL CONSUMPTION BY SIC CODE (1000 BARRELS)	D. FUEL OIL CAL. EQUIVALENT 1 BARREL = 1.46 x 10 ⁹ CAL.)	E. NATIONAL TOTAL NATURAL GAS CONSUMPTION BY SIC (BILLION FT ³)	F. NATURAL GAS EQUIVALENT ⁵ CAL. (1 CU. FT. = 2.60 x 10 ¹⁰ CAL.)	G. COMBINED FUEL OIL AND NATURAL GAS D + F	H. COMBINED FUEL OIL AND NATURAL GAS ENERGY CONSUMPTION OF INDIVIDUAL MANUFACTURER A x C B	I. TOTAL ESTIMATED INDUSTRIAL FUEL OIL AND NATURAL GAS CONSUMPTION BY CITY OR TOWN
Calxico	Calxico Chronical Western Guard Mexico	2711 Newspapers 3621 Motors and Generators	6 —	348.5 90.3	261.2 137.8	3.81 x 10 ¹⁴	8.4 9.0	21.84 x 10 ¹⁴	25.65 x 10 ¹⁴	.44 x 10 ¹¹ }	.44 x 10 ¹¹
EAST MESA	(See "Brawley," "Imperial," and "El Centro," Above)										
BORDER	No Industry										
SESPE	Corland Fleming, Inc.	3523 Farm Machinery	15	104.6	299.7	4.38 x 10 ¹⁴	17.4	45.24 x 10 ¹⁴	49.62 x 10 ¹⁴	7.12 x 10 ¹¹ }	
Palmore	Palmore Herald	2711 Newspapers	5	348.5	261.2	3.81 x 10 ¹⁴	8.4	21.84 x 10 ¹⁴	25.65 x 10 ¹⁴	.37 x 10 ¹¹ }	8.56 x 10 ¹¹
Santa Paula	Hoyle Engineering Co.	3811 Engineering Scientific Instruments	5	36.7	254.8	3.72 x 10 ¹⁴	1.6	4.16 x 10 ¹⁴	7.88 x 10 ¹⁴	1.07 x 10 ¹¹ }	
	Associated Concrete Products	3272 Concrete Products, n.e.c.***	400 T**	67.7	746.6	10.90 x 10 ¹⁴	6.9	17.94 x 10 ¹⁴	28.84 x 10 ¹⁴	170.40 x 10 ¹¹ }	
	Golden Manufacturing Corp.	3949 Sporting and Athletic Goods, n.e.c.***	7	61.0	112.5	1.64 x 10 ¹⁴	3.0	7.80 x 10 ¹⁴	9.44 x 10 ¹⁴	1.08 x 10 ¹¹ }	
	Livingston - Ophelm	3272 Concrete Products, n.e.c.***	610 T**	67.7	746.6	10.90 x 10 ¹⁴	6.9	17.94 x 10 ¹⁴	28.84 x 10 ¹⁴	259.86 x 10 ¹¹ }	633.10 x 10 ¹¹
	Prescon Corp.	3270 Concrete, Gypsum, Plaster Products	50	193.1	6,897.3	100.70 x 10 ¹⁴	85.6	222.56 x 10 ¹⁴	323.26 x 10 ¹⁴	83.70 x 10 ¹¹ }	
Simi Valley	Santa Paula Daily Chronicle	2711 Newspapers	41	348.5	261.2	3.81 x 10 ¹⁴	8.4	21.84 x 10 ¹⁴	25.65 x 10 ¹⁴	3.02 x 10 ¹¹ }	
	Weyerhaeuser Co.	2435 & 2436 Veneer and Plywood	150	68.8	444.2	6.49 x 10 ¹⁴	17.8	46.28 x 10 ¹⁴	52.77 x 10 ¹⁴	115.04 x 10 ¹¹ }	
	Benedict Must Publications	2721 Periodicals	6	66.5	19.6	.29 x 10 ¹⁴	1.0	2.60 x 10 ¹⁴	2.89 x 10 ¹⁴	.26 x 10 ¹¹ }	
	Free Drop Top, Inc.	3079 Misc. Plastic Products	47	346.9	1,377.7	20.11 x 10 ¹⁴	27.0	70.20 x 10 ¹⁴	90.31 x 10 ¹⁴	12.24 x 10 ¹¹ }	12.78 x 10 ¹¹
	Hammond Dental Mfg. Co.	3843 Dental Equipment & Supplies	3	12.4	8.0	.12 x 10 ¹⁴	.4	1.04 x 10 ¹⁴	1.16 x 10 ¹⁴	.28 x 10 ¹¹ }	
Ojai	Ojai Industrial Tools, Inc.	3544 Special Dies, Tools, Jigs, Fixtures	40	97.8	190.9	2.79 x 10 ¹⁴	6.2	16.12 x 10 ¹⁴	18.91 x 10 ¹⁴	7.73 x 10 ¹¹ }	8.91 x 10 ¹¹
Camarillo	Ojai Valley News	2711 Newspapers	16	348.5	261.2	3.81 x 10 ¹⁴	8.4	21.84 x 10 ¹⁴	25.65 x 10 ¹⁴	1.18 x 10 ¹¹ }	
	Camarillo Daily News	2711 Newspapers	50	348.5	261.2	3.81 x 10 ¹⁴	8.4	21.84 x 10 ¹⁴	25.65 x 10 ¹⁴	3.68 x 10 ¹¹ }	
	Clifford Industries, Inc.	3679 Electronic Components, n.e.c.***	18	100.5	956.7	13.97 x 10 ¹⁴	6.4	16.64 x 10 ¹⁴	30.61 x 10 ¹⁴	5.48 x 10 ¹¹ }	480.87 x 10 ¹¹
	Custom Electronic Design	3674 Semiconductors	10	97.6	279.8	4.09 x 10 ¹⁴	3.4	8.84 x 10 ¹⁴	12.93 x 10 ¹⁴	1.32 x 10 ¹¹ }	
	Minnesota Mining & Mfg. Co.	3679 Electronic Components, n.e.c.***	650 T**	100.5	956.7	13.97 x 10 ¹⁴	6.4	16.64 x 10 ¹⁴	30.61 x 10 ¹⁴	197.96 x 10 ¹¹ }	
Thousand Oaks	Monier-Raymond Concrete Tile	3271 Concrete Block & Brick	250 T**	22.8	65.1	9.51 x 10 ¹⁴	5.9	15.34 x 10 ¹⁴	24.85 x 10 ¹⁴	272.43 x 10 ¹¹ }	
	Cathy Accessories, Inc.	2396 Automotive and Apparel Trimmings	125	27.6	35.3	.52 x 10 ¹⁴	.8	2.08 x 10 ¹⁴	2.60 x 10 ¹⁴	11.75 x 10 ¹¹ }	70.64 x 10 ¹¹
	Scripps John P. Newspapers	2711 Newspapers	800 T**	348.5	261.2	3.81 x 10 ¹⁴	8.4	21.84 x 10 ¹⁴	25.65 x 10 ¹⁴	58.89 x 10 ¹¹ }	
LONG VALLEY:											
Mammoth Lakes	Haddaway Mfg.	3561 Pumps and Compressors	6	55.5	260.0	3.80 x 10 ¹⁴	7.1	18.46 x 10 ¹⁴	22.46 x 10 ¹⁴	2.41 x 10 ¹¹ }	2.41 x 10 ¹¹
Red's Meadow	(See "Mammoth Lakes," Above)										

*Withheld because the estimate did not meet U.S. Department of Commerce publication standards.

**Total employment for all branch plants and main plant (where data for individual plant is not readily available.)

***Not elsewhere classified.

TABLE A-6
INDUSTRIAL PRODUCTION (BY COUNTY)

	COUNTY	AREA (Sq. Miles, 1970)	INDUSTRY	1972 ⁽⁸⁾		1972 ⁽⁸⁾		1967 ⁽⁸⁾	
				ESTABLISHMENTS		ALL EMPLOYEES (1,000)	VALUE ADDED BY MANUFACTURE (Million Dollars)	ALL EMPLOYEES (1,000)	VALUE ADDED BY MANUFACTURE (Million Dollars)
				TOTAL NUMBER	WITH 20 EMPLOYEES OR MORE				
Salton Sea	Riverside	7,176	TOTAL	522	164	20.7	328.8	16.7	197.9
			Food and Kindred Products	44	13	1.2	19.7	1.1	15.1
			Lumber and Wood Products	57	28	2.9	42.1	(NA)**	(NA)
			Millwork, Plywood, Struc. Membs.	25	6	(D)*	(D)	(NA)	(NA)
			Wood Buildings and Mobile Homes	23	21	2.3	34.2	(NA)	(NA)
			Printing and Publishing	68	14	1.6	28.4	1.2	18.3
			Newspapers	18	7	1.1	20.5	.9	14.0
			Rubber, Misc. Plastics Products	15	8	.6	7.3	(NA)	(NA)
			Stone, Clay, Glass Products	45	18	2.2	46.0	1.5	23.3
			Structural Clay Products	6	5	(D)	(D)	(NA)	(NA)
			Concrete, Gypsum, Plaster Products	28	8	.7	19.4	(NA)	(NA)
			Primary Metal Industries	16	10	2.1	39.1	(NA)	(NA)
			Fabricated Metal Products	47	11	1.0	16.4	(NA)	(NA)
			Machinery, Except Electrical	55	9	1.0	13.7	1.0	12.0
			Transport Equipment	52	21	2.7	40.9	(NA)	(NA)
			Misc. Transportation Equipment	24	10	.8	13.6	(NA)	(NA)
	San Diego	4,261	San Diego SMSA Total	1400	363	64.7	1185.2	63.5	803.8
	Imperial	4,241	TOTAL	59	13	1.4	38.9	1.3	22.0
			Food and Kindred Products	22	8	.6	16.3	.6	12.0
Brawley, Heber, Border, East Mesa			See "Imperial County" above.						
Sespe	Ventura	1,864	Oxnard SMSA TOTAL	308	107	14.8	288.5	(NA)	(NA)
Coso H.S.	Inyo	10,130	TOTAL	207	74	7.7	167.9	5.4	76.2
	Tulare	4,812	Food and Kindred Products	42	19	1.5	37.7	1.4	24.0
			Preserved Fruits & Vegetables	11	6	.6	17.4	(NA)	(NA)
			Lumber and Wood Products	35	11	1.1	37.3	(NA)	(NA)
			Sawmills and Planing Mills	6	4	.6	20.5	(NA)	(NA)
			Printing and Publishing	23	10	1.6	29.4	.8	12.7
			Manifold Business Forms	3	3	.6	17.3	(NA)	(NA)
			Primary Metal Industries	6	5	.5	14.6	(NA)	(NA)
			Fabricated Metal Products	17	6	.5	14.4	(NA)	(NA)
			Electric, Electronic Equipment	7	5	.8	13.9	(NA)	(NA)
			TOTAL	57	16	2.1	47.2	1.2	29.5
			Food and Kindred Products	18	6	1.0	24.4	.6	21.2
Red's Meadow & Long Meadow	Mono Madera	3,027 2,145	Fresno SMSA TOTAL	537	164	18.6	408.3	15.5	227.0
	Fresno	5,966							

* Deleted to avoid disclosing figures for individual companies

** Not available

TABLE A-6
PETROLEUM AND NATURAL GAS PRODUCTION (BY COUNTY)

	COUNTY	NUMBER OF PRODUCING WELLS ⁽⁹⁾		PRODUCTION ⁽⁹⁾		
		OIL (AVERAGE)	DRY GAS (MAXIMUM)	PETROLEUM (THOUSAND BARRELS)	NATURAL GAS (NET)	
					OIL ZONES (MILLION CU. FT.)	DRY GAS ZONES (MILLION CU. FT.)
Salton Sea	Riverside	15	5	116	61	325
	San Diego	-	-	-	-	-
	Imperial	-	-	-	-	-
Brawley, Heber Border, East Mesa			See "Imperial County," above			
Sespe	Ventura	2671	4	23,722	27,705	966
Coso H.S.	Inyo	-	-	-	-	-
	Tulare	24	19	41	-	1464
Red's Meadow & Long Meadow	Mono	-	-	-	-	-
	Madera	-	15	-	-	3,127
	Fresno	2598	2	13,578	11,238	469

TABLE A-7
GEOTHERMAL RESERVOIR CHARACTERISTICS⁽²⁾

LOCATION			TEMPERATURE °C			RESERVOIR ASSUMPTIONS					COMMENTS
NAME	LATITUDE ° N	LONGITUDE ° W	SURFACE (2)	GEOCHEMICAL		SUB- SURFACE (4)	SUB- SURFACE AREA km ² (5)	THICKNESS km(6)	VOLUME km ³ (7)	HEAT CONTENT 10 ¹⁸ cal (8)	
				(3) SiO ₂	(3) Na-K-Ca						
Salton Sea	33 12	115 36	101			340	54	2	108	21	Many low-temperature seeps; 1 group to 101°C, now under Salton Sea; numerous drill holes to 2400 m and temperatures to 360°C in hypersaline brine.
Brawley	33 01	115 31				200	18	1.5	27	3	No surface discharge, reported high temperature based on old oil test; size based on temperature-gradient survey.
Heber	32 43	115 31.7				190	50	2	100	11	No surface discharge; much active exploration but no data released; estimated using temperature gradient data and exploration activity.
East Mesa	32 47	115 15				180	28	2	56	5.5	No surface discharge; temperature estimated using drilling data, volume from temperature gradient data and drill-hole data.
Border	32 44	115 07.6				160	3	.6	1.8	0.2	No surface discharge; estimated from temperature gradient data and extrapolation of East Mesa geology.
Sespe H.S.	34 35.7	118 59.9	90	133	155	155	1.5	1.5	2.25	.2	4 hot springs flowing 470 lpm.
Coso H.S.	36 03	117 47	95	161	238	220	168	2	336	41	1 group of hot springs; weak fumarole areas; geophysics indicates may be a very large system.
Red's Meadow	37 37	119 04.5	49	161	130	165	1.5	1.5	2.25	.2	5 springs flowing 38 lpm.
Long Valley	37 40	118 52	94	219	238	220	225	2	450	55	Springs and fumaroles in area of about 10 km ² . Recent caldera; about 10 wells drilled, reported to 181°C, extensive geology and geophysics.

(1) Identified Hot-Water Convection Systems with Indicated Subsurface Temperatures above 150°C.

(2) Maximum surface temperature reported from a spring or fumarole.

(3) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO₂ with respect to quartz, and no loss of Ca from calcite deposition.

(4) Assumed average reservoir temperature based on data presently available.

(5) From surface manifestations, geophysical data, well records and geologic inference. Assumes 1.5 km² if no data pertinent to size is available.

(6) Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems.

(7) Calculated from assumed area and thickness.

(8) Calculated as product of assumed volume, volumetric specific heat of 0.6 cal/cm³ °C, and temperature in degrees C above 15°C.

TABLE A-8
ENERGY AND UTILITIES

	EXPENDITURES FOR PETROLEUM PRODUCTS 1964 ⁽²⁾	FOSSIL FUELS IN AREA ⁽²⁾	EXISTING GEOTHERMAL DEVELOPMENT ACTIVITY ⁽¹⁰⁾	POWER GENERATION AND TRANSMISSION: (GT: GAS TURBINE, IC: INTERNAL COMBUSTION ST: STEAM, HY: HYDROELECTRIC) ⁽¹¹⁾
Salton Sea	\$1,500,000 & over	Salton Sea: gas field	Yes.	Coachella: 20 mi. N. of Sea. 46.3 Mw GT, municipal Brawley: 20 mi. SE. of Sea 13.3 Mw IC, 22.5 GT El Centro: 25 mi. S. of Sea 187.6 Mw St., municipal
Brawley Heber Border East Mesa	See above	-----	Brawley, Heber East Mesa = yes. (East Mesa Federal lease applica- tions). Border = no	See "Brawley" above. El Centro (above) 5 mi. S. of Brawley
Sespe	\$1,500,000 & over	Oil fields S. of Sespe	No	Castaic: 15 mi. E. of Sespe 268.5 Mw Hy, 425.0 Mw Hy, municipal San Francisquito No. 1: 25 mi. E. of Sespe 59.1 Mw Hy, municipal San Francisquito No. 2: 25 mi. E. of Sespe 42.0 Mw Hy, municipal Mandalay: 25 mi. S.W. of Sespe 435.2 Mw St, 138.1 Mw GT, private Ormond Beach: 25 mi. S.W. of Sespe 1612.8 Mw St., private
Cose H.S.	\$259,000 and under in Inyo Co. \$1,500,000 & over in Tulare Co.	-----	Yes	Kern River #3: 20 mi. S.W. 32 Mw Hy, private Trona: 30 mi. S.E. 45.1 Mw St, industrial
Red's Meadow	\$249,000 and under in Mono Co. \$1,500,000 and over in Madera and Fresno Co.	-----	Yes	Upper Gorge, 5-10 mi. E. of Red's Meadow 37.5 Mw Hy, municipal Middle Gorge, 5-10 mi. E. of Red's Meadow 37.5 Mw Hy, municipal Control Gorge, 5-10 mi. S.E. 37.5 Mw Hy, municipal
Long Valley	See "Red's Meadow" above	-----	Yes (Federal lease applica- tion)	Upper Gorge, 10-15 mi. S.E. of Long Valley; Middle Gorge, 12-17 mi. S.E. of Long Valley; Control Gorge, 20-25 mi. S.E. of Long Valley; See "Red's Meadow" above

TABLE A-9
POPULATION AND DEGREE DAYS

<u>Site</u>	<u>Population Centers (within 30 mi. of site)</u>	<u>Population</u> ⁽⁵⁾	<u>Heating Degree Days</u> ⁽⁴⁾	<u>Cooling Degree Days</u> ⁽⁴⁾
Salton Sea	Niland	950	1000-2000	3000-4000
	Calipatria	1,824		
	Westmoreland	1,417		
	Mecca	400		
	Thermal	600		
	Salton City	900		
	Brawley	14,300		
	Imperial	<u>3,202</u>		
	TOTAL	23,593		
Brawley	Brawley	14,300	"	"
	Westmorland	1,417		
	Imperial	3,202		
	Calipatria	1,824		
	El Centro	21,100		
	Holtville	3,496		
	Seeley	<u>950</u>		
	TOTAL	46,289		
Heber	Heber	950	"	"
	El Centro	21,100		
	Seeley	950		
	Calexico	13,000		
	Holtville	3,496		
	Imperial	<u>3,202</u>		
	TOTAL	42,698		
Border	Border	-	"	"
	East Mesa	-		
East Mesa	East Mesa	-	"	"
	Border	-		
	Holtville	3,496		
	Brawley	14,300		
	Calexico	13,000		
	El Centro	<u>21,100</u>		
	TOTAL	51,896		

TABLE A-9 (Concluded)

<u>Site</u>	<u>Population Centers (within 30 mi. of site)</u>	<u>Population</u>	<u>Heating Degree Days</u>	<u>Cooling Degree Days</u>
Sespe	Sespe	300	2000-3000	500-1000
	Fillmore	6,621		
	Santa Paula	18,700		
	Moorpark	3,380		
	Piru	990		
	Somis	600		
	Camarillo	23,300		
	Saticoy	-		
	Ojai	5,591		
	Thousand Oaks	54,500		
	TOTAL	113,982		
Coso	Haiwee	30	4000-6000	500-1000
	Olancha	260		
	Cartago	90		
	TOTAL	380		
Red's Meadow	Mammoth Lakes	900	8000-1000	0-500
	Tom's Place	30		
	TOTAL	930		
Long Valley	Mammoth Lakes	900	8000-9000	0-500
	Tom's Place	30		
	TOTAL	930		

TABLE A-10

AIR AND WATER QUALITY

<u>Site</u>	<u>Water Basin</u>	<u>Water Resources</u> ⁽¹²⁾	<u>Air Pollution Days</u> ⁽⁴⁾
Salton Sea Brawley Heber Border East Mesa	Colorado Desert	High salinity rate in water supply, water management problems of the Columbia River estuary and main-stem system. (>50% of stream miles polluted)	10-20 days of high air pollution potential forecasted.
Sespe H.S.	Central and South Coastal Sub-basin	20-49.9% of stream miles polluted (water atlas).	20-30 days of high air pollution forecasted, high suspended particles and sulphur dioxide (from L.A. area).
Coso	Central Valley Sub-basin	State vs. Federal water jurisdiction disputes. Deterioration of surface water quality. Some ground water overdraft, and land subsidence.	30-40 days of high air pollution potential forecasted.
Red's Meadow Long Valley	Lahontan Sub-basin	--	50-60 days of high air pollution potential forecasted.

APPENDIX B

EVALUATION AND SCORING

Once the site transformation table defined in Section 3 is compiled, the evaluation and scoring stage can begin. For this stage an evaluation table (Table B-1) may be used. A score is given to each characteristic in the table. The score depends on two factors:

- (1) The suitability of the resource for development independent of the industry.
- (2) The degree of matching of the specific source to the specific industry.

The scores presented in Table B-1 and explained in Table B-2 are preliminary. The data needed to confirm their validity are not presently available. It should be expected that this preliminary scoring procedure will be changed as data are collected and the procedure is refined by use.

The sum of the scores in any one row is the total for the particular criterion associated with the row. After a total score is obtained for each row, the scores are weighted by a relative importance factor. These latter numbers, when summed, will give an overall score for the site/industry application. A sum of the scores for all the industries considered for a particular reservoir will give an index for that site.

Discussion of Scoring

The factors considered in the generation of the scores for each element in the evaluation matrix are; in order of importance:

- (1) Impact of the substitution of geothermal energy on fuel imports and on fuel savings.
- (2) The suitability of the geothermal brine, as is, without modifications, for a particular application.
- (3) Local conditions, i.e., the degree of industrialization, availability of labor and raw materials, capacity of the transportation system, and laws and regulations.
- (4) Modifications of pollution patterns. It is assumed that all industries considered will meet local, state, and Federal standards; however, variations in the pollution patterns are permitted.
- (5) The desirability of the region to attract people and labor.

Based on the above considerations, scores for each element of the evaluation matrix were arbitrarily generated. Table B-2 defines the elements of each of these criteria and explains the scoring system. A score of +100 points was considered highly desirable and -100 highly undesirable. The scoring was so designed that a particular site/industry combination may have scores that can range from very large negative numbers to very large positive numbers (i.e., there is no maximum or minimum score), and in a group of these, those with the highest numbers will be most desirable.

The Weighting Procedure

To determine a weight for each criterion, as described in Appendix C, an emphasis curve was generated by polling ten members of the MITRE Geothermal Group. Although this method works best when the criteria vary little in importance between them, it did allow the ranking of the criteria and the generation of preliminary weights

(shown in Table B-1) for use in the early stages of the evaluation phase. Again those weights must be revised if found unsatisfactory.

TABLE B-1
EVALUATION SOURCE-INDUSTRY COMBINATION

RESOURCE: _____ INDUSTRY: _____

							SCORE	RELATIVE IMPORTANCE WEIGHTING	WEIGHTED SCORE
SOURCE CHARACTERISTICS	MODIFICATION OF TEMPERATURE	MODIFICATION OF FLOW RATE	MODIFICATION OF SALINITY	MODIFICATION OF PRESSURE PUMP	WELL DEPTH	LIFETIME AT REQ'D USE PROFILE	$\sum_{j=1}^6 s_{1,j}$	w_1 (17)	$w_1 \sum_{j=1}^6 s_{1,j}$
	$s_{1,1}$	$s_{1,2}$	$s_{1,3}$	$s_{1,4}$	$s_{1,5}$	$s_{1,6}$			
ENERGY SUPPLY	NUMBER OF BARREL EQUIVALENT SAVINGS	NUMBER OF BARREL EQUIVALENT SAVINGS	MODIFICATION OF POWER GENERATION & TRANSMISSION	NEED FOR ENERGY SUPPLY RELIAB.	EXPANSION RATE MODERATE	DISTANCE TO RESOURCE	$\sum_{j=1}^6 s_{2,j}$	w_2 (12)	$w_2 \sum_{j=1}^6 s_{2,j}$
	$s_{2,1}$	$s_{2,2}$	$s_{2,3}$	$s_{2,4}$	$s_{2,5}$	$s_{2,6}$			
EXISTING INDUSTRY	RELATED INDUSTRY	UNRELATED INDUSTRY	---	---	---	---	$\sum_{j=1}^2 s_{3,j}$	w_3 (12)	$w_3 \sum_{j=1}^2 s_{3,j}$
	$s_{3,1}$	$s_{3,2}$							
LOCAL RAW MATERIALS	MODIFICATIONS OF LOCAL PRODUCTION	MODIFICATIONS OF LOCAL PRODUCTION	MODIFICATION OF LOCAL PRODUCTION	---	---	---	$\sum_{j=1}^3 s_{4,j}$	w_4 (10)	$w_4 \sum_{j=1}^3 s_{4,j}$
	$s_{4,1}$	$s_{4,2}$	$s_{4,3}$						
LAND USE	MODIFICATIONS LAND DISTRIBUTION	MODIFICATIONS TO LAND USE	REQUIRED MINERAL LEASES	---	---	---	$\sum_{j=1}^3 s_{5,j}$	w_5 (9)	$w_5 \sum_{j=1}^3 s_{5,j}$
	$s_{5,1}$	$s_{5,2}$	$s_{5,3}$						
CLIMATE	SUITABILITY OF TEMP. EXCURSIONS	WIND OBJECTIONABILITY	RAIN SUFFICIENCY	---	---	---	$\sum_{j=1}^3 s_{6,j}$	w_6 (2)	$w_6 \sum_{j=1}^3 s_{6,j}$
	$s_{6,1}$	$s_{6,2}$	$s_{6,3}$						
ENVIRONMENTAL	MODIFICATION OF WATER POLLUTION LEVELS	MODIFICATION OF AIR QUALITY	USEABILITY OF SOLID REFUSE GENERATED	EXPECTED SEISMIC ACTIVITY	---	---	$\sum_{j=1}^4 s_{7,j}$	w_7 (8)	$w_7 \sum_{j=1}^4 s_{7,j}$
	$s_{7,1}$	$s_{7,2}$	$s_{7,3}$	$s_{7,4}$					
TRANSPORTATION	ADEQUACY OF HIGHWAYS	ADEQUACY OF RAILROADS	ADEQUACY OF CANAL SYSTEM	ADEQUACY OF PORT FACILITIES	---	---	$\sum_{j=1}^4 s_{8,j}$	w_8 (6)	$w_8 s_{8,1}$
	$s_{8,1}$	$s_{8,2}$	$s_{8,3}$	$s_{8,4}$					
DEMOGRAPHIC	POPULATION SIZE	MODIFICATION OF LABOR FORCE	ATTITUDES OF CONCERNED AGENCIES	MODIFICATIONS TO COMMUNITY SERVICES	ATTITUDE OF THE POPULATION	---	$\sum_{j=1}^5 s_{9,j}$	w_9 (8)	$w_9 \sum_{j=1}^5 s_{9,j}$
	$s_{9,1}$	$s_{9,2}$	$s_{9,3}$	$s_{9,4}$	$s_{9,5}$				
INSTITUTIONAL	MODIFICATION OF LAWS, STATUTES AND/OR REGS.	ATTITUDE OF LOCAL GOVERNMENT	---	---	---	---	$\sum_{j=1}^2 s_{10,j}$	w_{10} (8)	$w_{10} \sum_{j=1}^3 s_{10,j}$
	$s_{10,1}$	$s_{10,2}$							
ECONOMIC	FINANCIAL INSTITUTIONS	---	---	---	---	---	$s_{11,j}$	w_{11} (3)	$\sum_{j=1}^2 w_{11} s_{11,j}$
	$s_{11,1}$								
TOTAL SCORE									$\sum_{j=1}^{11} \sum_{i=1}^N w_i s_{i,j}$

CRITERION
AND WEIGHTW₁ = 17%SOURCE
CHARACTERISTICSTABLE
ENTRY
NO.

CHARACTERISTIC

SCORE

REASON

S_{1,1}

Temperature

-50 for additional heating
 -15 for cooling
 +10 if within temperature
 limits
 0 if at lowest tolerable
 limits

If a process requires modification
 of the brine temperature, additional
 equipment (heat exchangers) must be
 installed

S_{1,2}

Flow Rate

-50 for increase beyond
 well capacity
 -15 for modifications
 within well capacity
 +10 if within required
 limits
 0 if close to lowest
 tolerable limit

Modification of the flow rate will
 also require installation of addi-
 tional equipment. In this case
 additional penalty points are given
 to increasing the flow rate beyond
 the capacity of the well, requiring
 the drilling of additional wells

S_{1,3}

Salinity

-100 if not tolerable
 -20 if secondary working
 fluid required
 +100 if process will tol-
 erate high salinity
 +10 if salinity within
 tolerance

Installation of desalinization
 equipment is considered highly
 undesirable. A heat exchanger may
 be used to heat a secondary working
 fluid. A process insensitive to
 salinity is considered highly
 desirable

TABLE B-2
 RESOURCE SITE/INDUSTRY SCORES

CRITERION
AND WEIGHT

$W_1 = 17\%$

SOURCE
CHARACTERISTICS

TABLE B-2 (Cont'd)

TABLE ENTRY NO.	CHARACTERISTIC	SCORE	REASON
S _{1,4}	Pressure	<p>-50 if downhole pump required</p> <p>-25 if surface pump required</p> <p>+20 if process will tolerate flash</p> <p>+ 10 if pressure within limits</p> <p>0 if pressure near allowable limits</p>	Due to the poor reliability of high temperature downhole pumps to date, they are considered less desirable than surface pumps. A process that will tolerate steam mixed with the brine is more desirable than one which can operate on fluids only
S _{1,5}	Well Depth	50 $(1 - \frac{d}{3000})$ where d is the well depth in feet	An average geothermal well is about 3,000 ft. deep. Hence a well shallower than 3,000 ft. is more desirable than one deeper. The 3,000 ft. cut-off should be modified for geopressured wells, where the average is around 12,000 ft.
S _{1,6}	Lifetime	50 $(1 - \frac{100 QR}{Q})$ where QR is the yearly energy consumption of the industry. Q is the estimated energy content of the reservoir	In non-electric applications, it is possible to recover up to 25 percent of the heat content of the reservoir. The equation also reflects the fact that a reservoir must have sufficient energy to operate the industry for at least 25 years

TABLE B-2 (Cont'd)

CRITERION AND WEIGHT	TABLE ENTRY NO.	CHARACTERISTIC	SCORE	REASON
ENERGY SUPPLY $W_2 = 12\%$	S _{2,1}	Savings in Oil and Natural Gas	$100 \left(\frac{C}{1000} \right)$ where C is the estimated oil and natural gas saved by use of geothermal energy in equivalent BBL/day	The present oil and natural gas consumption in the U.S. is around 30 million equivalent BBL/day. In the equation, 100 points are given for each 1,000 equivalent BBL/day savings (1/30,000 of the daily consumption).
	S _{2,2}	Savings in Other Fuels	$25 \left(\frac{C}{350} \right)$ where C is the actual other fuels saved by use of geothermal energy	Present U. S. consumption of other fuels is around 10 million equivalent BBL/day. Since this supply is not in jeopardy, 25 points are given for a substitution of 1/30,000 of the daily consumption.
	S _{2,3}	Power Transmission System	-50 if major expansion is required 0 otherwise +50 if transmission system can handle power when generation is considered	New industry may require major modifications to the electrical network. Sites in which modifications are not required are naturally more desirable. A site whose network can handle additional power generated geothermally is also more desirable.

TABLE B-2 (Cont'd)

CRITERION AND WEIGHT	TABLE ENTRY NO.	CHARACTERISTIC	SCORE	REASON
ENERGY SUPPLY $W_2 = 12\%$	$S_{2,4}$	Supply Reliability	+20 if 100% is achieved by use of the geothermal source and 100% reliability is required by the process. 0 if 100% reliability not require. -20 if reliability is decreased by use of geothermal energy.	Some processes require 24 hour operation and hence 100% reliability for the energy source. In that case, the geothermal source may provide the required reliability. On the other hand, it is possible that the use of geothermal brine may result in decrease of reliability because of corrosive effects of the brine.
	$S_{2,5}$	Expansion Rate	$r (S_{2,1} + S_{2,2} + S_{2,4})$ where r is the fractional expansion rate of energy demand by the process	
	$S_{2,6}$	Distance to Resource	$50. (1 - \frac{D}{20})$ where D is distance to well in miles	If the source is not adjacent to the factory where the brine is to be used, the brine must be piped. This will result in a loss of energy as well as additional installation costs.

TABLE B-2. (Cont'd)

CRITERION AND WEIGHT	TABLE ENTRY NO.	CHARACTERISTIC	SCORE	REASON
EXISTING INDUSTRY $W_3 = 12\%$	S _{3,1}	Related Industry	+30 for each related industry whether complementary or competitive	The availability of related industry in the region has many advantages including cost savings in transportation, labor availability, common imports, etc.
	S _{3,2}	Unrelated Industry	+5 for each unrelated industry	The presence of unrelated industry in the region is a measure of the degree of commercialization of the region.
LOCAL RAW MATERIALS $W_4 = 10\%$	S _{4,1}	Existing Raw Materials for Related Industries	+50 if modification in raw material production advantageous to region, -50 if not 0 if neither	A certain process may require modifications in the raw material production of the region (e.g., increase of beet production for a sugar factory). Such modification may improve the standard of living in the region, such as provide additional jobs, make use of uncultivated land, etc., or it may have the opposite effect.
	S _{4,2}	Raw Materials for Unrelated Industry	Same as above	Same as above

TABLE B-2 (Cont'd)

CRITERION AND WEIGHT	TABLE ENTRY NO.	CHARACTERISTIC	SCORE	REASON
	S _{4,3}	Existing Raw Materials that Can Be Processed	Same as above	A certain region may have the proper conditions to produce (or may be producing) a raw material that can be processed locally using geothermal energy.
LAND USE W ₅ = 9%	S _{5,1}	Land Distribution	-50 for modifications +50 if no modifications required	Any modifications in land distribution will require time and additional expenses thence delaying projects.
	S _{5,2}	Land Use	Same as above	Same as above
	S _{5,3}	Mineral Exploration Leases	+25 for each mineral lease	Leases are indicative of possible future development of the region.
	S _{6,1}	Temperature	+50 if desirable 0 if average -50 if undesirable	The daily and yearly temperature excursions and climate in general will have some influence on the potential of a region to attract additional labor when necessary.

TABLE B-2 (Cont'd)

CRITERION AND WEIGHT	TABLE ENTRY NO.	CHARACTERISTIC	SCORE	REASON
CLIMATE $W_6 = 2\%$	S _{6,2}	Wind	0 if OK -100 if intolerable	In most cases, the wind conditions should have very little effect on a process. In the case where it does and the wind is intolerable in the region a large penalty is assessed.
	S _{6,3}	Rain	0 if OK -100 if intolerable	Lack of sufficient rain may require that some raw materials be imported from other areas instead of being grown locally.
ENVIRONMENTAL $W_7 = 8\%$	S _{7,1}	Water Pollution	+100 if decreased -100 if increased 0 if no effect	For consideration, the process <u>must</u> meet all pollution requirements. This characteristic is intended to score possible variations within the standards.
	S _{7,2}	Air Quality	+100 if decreased 0- (-100) if increased 0 if no effect	Same as above
	S _{7,3}	Solid Refuse	+100 if usable 0 to -100 otherwise	The process may generate solid refuse which may be usable elsewhere or it may have to be disposed of.

TABLE B-2 (Cont'd)

CRITERION AND WEIGHT	TABLE ENTRY NO.	CHARACTERISTIC	SCORE	REASON
TRANSPORTATION $W_8 = 7\%$	S _{7,4}	Seismic Activity	-100 if damage to life or property likely	Reinjection will result in some seismic activity. This must be thoroughly investigated before the go-ahead is given on a project.
	S _{8,1}	Transportation System	+100 if adequate (all modes) 0 to -100 if modifica- tions required (any mode)	Any new industry will likely need to export its product and hence will require an adequate transportation system.
	S _{8,2}	Industrial Pro- ducts Center	+100 if no restrictions -100 if restrictions re- quire modifications	The proximity of the products center is of major importance for some in- dustries
	S _{8,3}	Commercial Pro- ducts Center	Same as above.	Same as above.
	S _{9,1}	Population Size	0 - 0 - 1,000 +10 - 1,000 - 2,500 +20 - 2,500 - 10,000 +30 - 10,000 - 50,000 +40 - 50,000 and over	The larger the population of a region the larger is the likelihood of finding labor, of finding finan- cing, of selling the product locally..

CRITERION
AND WEIGHT

W₁₀ = 9%

DEMOGRAPHIC

TABLE B-2 (Cont'd)

TABLE ENTRY NO.	CHARACTERISTIC	SCORE	REASON
S _{9,2}	Labor Force	-100 if labor force not available +50 if OK +100 if excess labor in area will be used by new project.	A project is considered highly desirable if it results in the employment of excess labor in the region
S _{9,3}	Potential Interveners	-100 for each opposed agency +50 for each agency in favor	As long as the public is unedu- cated in the area of geothermal energy, it can be easily manipu- lated by agencies/groups opposed to geothermal development; hence a heavy penalty is assessed for each agency that would oppose the development.
S _{9,4}	Community Services	+50 if sufficient 0 to -100 for expan- sion	Community services such as schools, libraries, utilities, etc., must be adequate for a favorable score.
S _{9,5}	Attitudes of Population	+100 if in favor 0 if indifferent -100 if opposed	A population which seems in favor of geothermal development is preferred to one opposed.

TABLE B-2 (Cont'd)

CRITERION	TABLE ENTRY NO.	CHARACTERISTIC	SCORE	REASON
INSTITUTIONAL $W_{10} = 11\%$	S _{10,1}	Laws, Statutes, and Regulations	+50 if unopposed 0 to -100 if modifications required	A negative grade ranging from 0 to -100 will be applied in cases where laws, statutes and/or regulations must be changed to accomodate geothermal development depending on the magnitude of the change.
	S _{10,2}	Attitude of Local Government	0 to -100 if against +50 if in favor	The position of the officials opposed to geothermal development should be used to determine the negative score in cases where the local government is opposed to geothermal development
ECONOMIC $W_{11} = 3\%$	S _{11,1}	Financial Institutions	+100 if will fund -100 if opposed to funding	If the project is considered desirable and financial institutions will not fund it, it will be the responsibility of ERDA to provide funding.

APPENDIX C

WEIGHTING PROCEDURE BY USE OF THE EMPHASIS CURVE

To determine the relative weight of some of the criteria used in this paper an emphasis curve technique was used. To illustrate the use of this method, assume that it is necessary to determine the relative importance of n criteria, $(C_1, C_2, \dots, C_n)$. The method consists of displaying these criteria in a triangular array as shown in Figure C-1 (shown for ten criteria). The evaluators are then asked to write in each square which is the intersection of C_i with C_j either C_i or C_j , whichever they believe is most important. The triangular array is designed to preclude more than one occurrence of the comparison between any two criteria. Hence the total number of squares in the array is:

$$\frac{n(n-1)}{2}$$

and the maximum possible times a criterion may appear in the array is $n-1$. Hence the maximum possible weight for any criterion is:

$$\frac{2}{n}$$

As n becomes large the important criteria will have relatively low weight. If the criteria are approximately equal in importance, the method can give relatively accurate weights. However, if the criteria differ significantly, then the method yields a ranking of the criteria only. Conversely, if the weights are close to each other then they should be a good indication of the relative importance of

the criteria. However, if large differences occur, then the weights should only be used to indicate the relative ranking of the criteria examined.

	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	C_3	C_2
C_1									
C_2									
C_3									
C_4									
C_5									
C_6									
C_7									
C_8									
C_9									
C_{10}									

FIGURE 6-1

TRIANGULAR ARRAY FOR PAIR-WISE
COMPARISON OF TEN CRITERIA

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