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Geothermal Industry Employment: Survey Results & Analysis

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INTRODUCTION

The Geothermal Energy Association (GEA) is often asked about the socioeconomic and employment impact of the industry. Since available literature dealing with employment involved in the geothermal sector appeared relatively outdated, unduly focused on certain activities of the industry (e.g. operation and maintenance of geothermal power plants) or poorly reliable, GEA, in consultation with the DOE, decided to conduct a new employment survey to provide better answers to these questions.

The main objective of this survey is to assess and characterize the current workforce involved in geothermal activities in the US. Several initiatives have therefore been undertaken to reach as many organizations involved in geothermal activities as possible and assess their current workforce.

The first section of this document describes the methodology used to contact the companies involved in the geothermal sector. The second section presents the survey results and analyses them. This analysis includes two major parts. The first part analyzes the survey responses, presents employment numbers that were captured and describes the major characteristics of the industry that have been identified. The second part of the analysis estimates the number of workers involved in companies that are active in the geothermal business but did not respond the survey or could not be reached. Preliminary conclusions and the study limits and restrictions are then presented.

The third section addresses the potential employment impact related to manufacturing and construction of new geothermal power facilities. Indirect and induced economic impacts related with such investment are also investigated.

MAJOR FINDINGS

In 2004 the geothermal industry supplied about 4583 direct jobs. This corresponds to 1.7 jobs per megawatt (MW) of geothermal power capacity installed. Employment in the industry is probably at a historic low since power plant construction has been minimal between 1993 and 2004 as state and federal policies underwent significant changes. Also, because federal research support is at a historically low level, associated research employment is low.

Looking forward, employment is likely to increase. More power purchase agreements have been signed for new geothermal power plants, and the powerful federal Production Tax Credit (PTC) has been expanded to include new geothermal facilities. These changes indicate that there will be significant new growth in the industry in coming years. Geothermal Energy Association's (GEA) geothermal employment survey, which informs this paper, allows for an estimate of the employment impact of future growth based upon the industry's profile in 2004.

New growth in the industry will not only create new direct power plant jobs, but will also create many equipment manufacturing, construction jobs, and opportunities for indirectly related businesses and support services. Employment generated by power plant manufacturing and construction is estimated at 6.4 person*year jobs per MW of new capacity installed.

The geothermal industry has the potential to stimulate substantial new employment. The Energy Information Administration (EIA) reference case scenario for the geothermal industry growth suggests that 2455 MW of new power production capacity will be built during the next 20 years. This would correspond to the creation of 15,713 person*year jobs directly related to power plant construction and manufacturing. In terms of permanent jobs, this increase would result in 8,764 full-time job equivalents of direct employment in the industry.

Direct-use applications of geothermal resources may also experience future growth from the increasing prices of alternative fuels, and could provide substantial new job opportunities not included in the above figures and projections.

Power plant construction as well as operation and maintenance involve the use of numerous goods and services provided from other economic and industrial sectors. Increased demand for those goods and services will result in indirect and induced employment impacts, both locally and nationwide.

Construction of a geothermal power plant takes about 17 to 33 months and involves many types of skilled workers. On-site construction typically concerns 3.1 person*year jobs per

MW. As stated by Calpine[1], a company with many California geothermal plants, the construction of a 50 MW power project may require 33 months and involve up to 160 workers. Labor requirements vary during the construction period and peak around the nineteenth month of construction. Typically, a majority of the construction and O&M workforce is hired locally. Once a power plant is built, employment directly related to operation and maintenance corresponds to 0.74 jobs/MW. Those jobs are steady and well-paid, usually located in remote areas characterized by high unemployment rates where few alternative jobs are available. These geothermal jobs bring highly appreciated revenues streams into the local community and provide new opportunities for economic development (e.g. increased catering and accommodation services, hardware stores, etc.). Despite its temporary nature, the construction phase provides similar economic development opportunities. Large projects may require infrastructure planning from nearby cities in order to adapt the public services (e.g. schools, medical care, firefighters, etc.) to a larger population and an influx of new construction workers. In some cases, geothermal power producers helped local communities improve the health-emergency and firefighter services. Other collaborations may take place: Calpine, for example, welcomes local community events in its visitor center at its power plants at The Geysers.

Economic multipliers capture the impacts of indirect and induced economic development triggered by new projects. The value of the multiplier depends upon the size and characteristics of the economy considered. Nationwide, the economic multiplier effect of new geothermal power projects is estimated at 2.5. This means that each dollar invested in geothermal development will result in an output growth of $2.5 for the U.S. economy. Statewide the multiplier is typically considered to range from 1.5 to 2. Similar methodology is use to assess indirect and induced employment impacts.

The choice of the most appropriate economic multiplier is beyond the scope of this paper, but for illustration purposes, if one assumes a multiplier of 2.5, the direct, indirect, and induced job impact of the industry in 2004 would be 11,460. Assuming the EIA projections of an increase of 2455MW (to total installed capacity of 5155MW), the permanent jobs in the industry and those induced by it would total 21,910. Similarly, the total manufacturing and construction employment impact created by the expansion of the geothermal industry would be equivalent to 39,280 person*year jobs.

The use of different measures for construction and manufacturing jobs is deliberate. While construction and manufacturing activities account for significant employment opportunities, they are typically concentrated at the power plant's initial years. The distinction between short term and long term employment is appropriate given the differing nature of the resulting employment.

Employment results are summarized in the following chart.

[1] Calpine, *"Fourmile Hill Geothermal Development Project – Environmental Impact Statement and Report"*, September 1998.

Geothermal Industry Employment Assessment Results
(*Projection Assumes EIA Projected Growth of Industry)

	2004	2026*
MW on-line	2,700	5,155
Direct, Permanent Employees	4,583	8,764
Direct, Indirect and Induced Employment	11,460	21,910
Additional Construction Employment	15,731 person*years	
Additional Construction w/ Induced Employment	39,280 person*years	

Highlights of Characteristics of Employment in the Geothermal Industry

During the conduct of the employment survey and subsequence analysis, it was possible determine certain characteristics of the geothermal industry in 2004. Some highlights are:

- Permanent full time employment represents 86% of total industry employment, permanent part time jobs account for 8.5%, temporary full time jobs for 2% and temporary part time jobs for 3.5%.

- The ten companies with the largest geothermal work force comprise roughly 40% of the direct employment in the industry.

- Over 90% of the companies involved in the geothermal industry have less than 20 employees in their geothermal workforce.

- Geothermal power producers are typically the largest employers in the industry.

- About half of the companies involved in the geothermal industry have research and development activities.

METHODOLOGY

1. Reaching as many geothermal organizations as possible:

In order to ensure that the largest number of organizations involved in geothermal activities could be reached, preliminary research focused on identifying, gathering and comparing existing lists of companies and associations. The Geothermal Resource Council (GRC) and Geothermal Energy Association (GEA) membership lists were crucial to compiling a first list of organizations involved in geothermal activities. However, since some lists and directories were discovered later in the survey process, a second major list of companies, largely inspired by the *"2001 Energy Technology Export Directory of California Companies",* published by the California Energy Commission (CEC) has been completed.

List 1 *(GRC-GEA list)* merges the Geothermal Resource Council and Geothermal Energy Association membership lists with a few modifications and additions. Contact information for organizations appearing in this list was of good reliability and provided relatively high response rates to the survey.

List 2 *(CEC-GEO list)* was put together later, as it appeared that the first list did not capture all organizations possibly active in the geothermal sector. It was designed as a complementary list with no overlap with the first list. Names of companies[2] appearing in the first list were therefore removed from the second. Given its nature, this CEC directory listed any company with possible interest in geothermal business. Additionally, contact information appeared much less reliable, sometimes incomplete or outdated. Both these observations suggested a change in the methodology used to contact these companies and resulted in a separate analysis of the response rate from both lists.

The survey has also been disseminated through GEA's website and newsletter, the Geo-Powering the West network as well as through the Geothermal-Biz newsletter.

2. Contacting companies and associations:

On July 16, 2004 a first mailing was sent to the GRC-GEA list. This mailing was followed by seven successive "follow-up emails" sent approximately every two weeks to the companies that had still not provided responses to the survey. In November 2004, in an ultimate attempt to reach these companies, personal phone calls were made to each company that did not respond to the survey.

On September 17, 2004 a first mailing was sent to the CEC-GEO list. This mailing was also followed by two "follow-up" emails. However, this strategy was not pursued since the email address of numerous companies was incorrect or missing. Systematic phone calls were thus made to companies to enhance the rate of response.

[2] In the following document, the word "company" refers to any kind of organization involved in geothermal activities, i.e. companies, associations, governmental agencies, research institutes, etc.

RESULTS AND ANALYSIS

1. Response rate:

A. The GRC-GEA list:

This list accounted for 242 different companies and 44 individuals. 60.3% of the contacted companies and 22.7% of the individuals responded positively to the survey. The significantly lower response rate of individuals can be explained by the fact that the individuals may be retired persons, students or people not actively working in the geothermal field.

Based on the kind of responses that could be obtained, companies are sorted into four different categories:
(a) Companies that filled out the survey and provided employment numbers;
(b) Companies that did not respond to the phone call but had a workable phone number;
(c) Companies that could not be contacted due to incorrect contact information;
(d) Companies that are not involved or have insignificant employment[3] involved in geothermal activities

Table 1: Different kind of responses from companies listed in the GRC-GEA list.

	Companies	Individuals
GRC-GEA list	***242 (100%)***	***44 (100%)***
Responded to the survey	146 (60%)	10 (23%)
Workable phone number	68 (28%)	16 (36%)
Not involved / insignificant workforce	13 (5%)	10 (23%)
Incorrect contact info / Not Interested	14 (6%)	8 (18%)

B. The CEC-GEO list:

The CEC-GEO list accounted for 223 additional companies. Only 19 of these provided positive responses to the survey (8.5%) following the mailing and emailing.

C. Other initiatives to broadcast the survey:

GEA Updates included articles and links to the survey. A highly visible link to the survey was also advertised on GEA's website and it allowed people to complete the survey online. In an ultimate attempt to reach companies that did not appear in the previous lists or did not visit GEA's website, an article presenting this research was included in the Geothermal-Biz newsletter which included a link to the online survey form. This, along with the distribution of the survey at the GEA-GRC annual trade show and the use of the Geo-Powering the West network to send emails yielded 20 additional responses to the survey. This exhausted the lists we could identify or access.

[3] In the following analysis, insignificant employment values correspond to workforce lower than 0.5 Full Time Equivalent (FTE).

2. Analysis of the Survey Results.

As suggested above, all companies involved in geothermal activities did not provide responses to the survey. This must be kept in mind when reading the analysis of the responses provided in this section. Attempts to assess employment that could not be captured in these responses are presented in the next section.

A. Preliminary screening:

195 organizations involved in geothermal activities responded successfully to the survey and provided employment numbers. Employment related to geothermal activities for these companies totaled 2642 jobs.

Since the survey also asked for total employment of these companies (i.e. employment related to all activities of the company, including activities outside geothermal business) it appears that geothermal employment only represents 0.64 % of the total workforce of these 195 companies which actually provide work to 410,592 persons. The relative importance of geothermal employment for these companies however varies significantly.

The top 10 companies having the largest number of employees totals 352,200 of these 410,592 jobs. However, only 519 of these 352,200 jobs are geothermal jobs. On the other hand, 92 companies have the majority of their workforce involved in geothermal activities and account for 1063 geothermal jobs and 1380 total jobs.

B. Employment type:

The survey questionnaire classified employment according to two parameters: full time jobs vs. part time jobs and permanent employment vs. temporary employment. As a result, a distinction may be made between four different kinds of employment. The following table summarizes results obtained:

Table 2: Classification for Geothermal Employment.

	Full time	Part time	*Total*
Permanent jobs	**2274**	**224**	*2498*
Temporary jobs	**52**	**92**	*144*
Total	*2326*	*316*	*2642*

As a result, permanent full time employment represents 86% of total industry employment, permanent part time jobs account for 8.5%, temporary full time jobs for 2% and temporary part time jobs for 3.5%.

C. Structure of the Geothermal Sector and Organization Characteristics:

a. Distribution of companies according to the size of their workforce involved in geothermal activities:

Table 3: Distribution of responses according to the company's workforce size.

Percentage of companies	Geothermal workforce size
65.6%	1 to 5 employees
16.7%	6 to 10 employees
8.9%	11 to 20 employees
3.6%	21 to 50 employees
2.1%	51 to 10 employees
3.1%	Over 100 employees

The 10 largest geothermal employers account for 1641 jobs (all full time jobs) and 9 of these 10 organizations are private companies. Accordingly, these companies account for 62% of the geothermal employment captured in this survey.

Geothermal power producers are typically the largest employers of the industry. They account for 1040 jobs (all full time jobs) or 39% of total captured geothermal employment. On average, geothermal power producers employ 0.49 workers per megawatt (MW) of net power capacity installed. This figure does not include subcontracted employment, which will be addressed later in this analysis.

On the other side, 28% of the responses accounted for only one geothermal job each. This geothermal employment was a full time position for 65% of the respondents and a part time job for the remaining 35%. Appendix B provides further details about workforce size and frequency involved in Private Companies and Independents & Consultants.

b. Distribution of responses according to the company type:

Distribution of respondents according to the type of company/association and their relative importance as employers is presented in the table below. As shown, private companies constitute the majority of the responses and account for a vast majority of total employment in the sector.

Table 4: Frequency of company type and respective importance as employer.

	Frequency of responses *(% of respondents)*	**Relative importance as employer** *(% employment captured by each category)*
Private Company	45.1 % (88 out of 195)	80.4% (2123 jobs out of 2642)
Independent / Consultant	25.6 % (50 out of 195)	7.2 % (190 jobs out of 2642)
Government Agency	14.1 % (28 out of 195)	7.1 % (187 jobs out of 2642)
Research Institution	8.2 % (16 out of 195)	3.5 % (93 jobs out of 2642)
Non Profit Association	4.1 % (8 out of 195)	0.8 % (22 jobs out of 2642)
Other	2.6 % (5 out of 195)	1.0 % (27 jobs out of 2642)

Among responses from government agencies, 9 are working at the Federal level, 13 at the State level and the 6 at local level. It is also noteworthy that private companies account for 84% of total full time employment. Further details concerning distribution and importance of employment throughout the various types of organizations are provided in Appendix 1.

Table 4 also reveals that the average geothermal workforce in private companies is 24 employees (i.e. 2123 jobs / 88 companies). The number falls sharply for all other categories: 6.7 for governmental agencies, 5.8 for research institutions, 3.8 for independents and consultants, and 2.8 for non-profit associations. As a whole, the average geothermal workforce for all organizations that responded the survey is 13.6.

c. Distribution of respondents according the relative importance of geothermal activities for their company:

One of the survey questions investigated the relative importance of geothermal activities for each responding organization. The following table sorts companies according to their responses and link that information with the percentage of total employment involved in each category:

Table 5: Relative importance of geothermal activities for companies that responded.

Relative importance of geothermal activities for the responding organization (% of total activities)	Frequency of responses (% of respondents corresponding to each category)	Percentage of employment related to each category (% of total employment)
Less than 1 %	20 % *(39 responses out of 195)*	21% *(555 jobs out of 2642)*
1 to 5 %	17 %	10%
6 to 25 %	21 %	24%
26 to 50 %	10 %	6%
51 to 75 %	5 %	1%
76 to 100 %	26 %	32%

It is also noteworthy that 15.6% of all these organizations have no activities outside the geothermal sector. This corresponds to 60% of the companies for which geothermal activities account for 76 to 100 % of their business activities. These companies having no activities outside the geothermal business account for 6 % of total employment involved in geothermal activities. This number reflects two important finding; First, many organizations totally focused on geothermal activities are of relatively small size. Second, geothermal power producers tend to be part of larger corporations for which geothermal activities may only be marginal.

d. Additional findings related to geothermal employment:

- 46 % of the responses stated that the organization had research and development activities. (54% did not)

- 36 % of the responding companies declared themselves to be active in consultants (64% did not offer consulting services)

- 22% of the responding companies are owned by a parent company.

- 19% of the responding companies have construction activities (81% do not)

- 14 % of the responding companies are directly involved in power plant operation and maintenance (86% are not). Geothermal employment of these companies account for 1197 jobs (of which 1181 are full time permanent jobs). 32.1% of these companies (or 4.5% of all responding companies) directly own geothermal power plants.

- 11% of the responding companies are involved in drilling activities. These companies account for 133 jobs (of which 105 are full time permanent jobs)

- 14% of the responding companies are involved in "direct use" applications of geothermal resources. These 28 organizations account for 193 jobs (of which 143 are full time permanent jobs). 43% of these companies are not entirely focused on direct use issues since 12 also declared themselves to be involved in power production activities.

3. Assessing employment not captured by the survey.

All companies involved in geothermal activities did not respond to the survey. It is therefore important to estimate employment related to the organizations that did not provide responses. The two following sections provide such assessments.

A. Estimating employment related to companies appearing in the GRC-GEA list that did not respond to the survey

Since each company on the GRC-GEA list that did not readily fill out the survey was contacted by phone to enhance the response rate, companies that did not respond to the survey could be sorted in three categories:
- Companies that had a working phone number but did not respond to the phone call (68)
- Companies that are not actively involved in geothermal business or have insignificant employment related to these activities[4] (13)
- Companies that could not be reached due to incorrect contact information (14).

As a reminder, 146 companies responded to the survey successfully, providing information about employment involved in geothermal activities.

The above information states that 13 companies responded that they had no employees actively involved in the geothermal business while 146 responded that they had at least 1 employee working on geothermal issues. This suggests that 92% of the companies that provided a clear response are actively working on geothermal issues while 8% are not.

[4] Most of these organizations responded that they were used to work on geothermal issues (and would be interested to continue to do so) or had interests in the industry but had no or no significant employment involved on geothermal activities in 2004.

Assuming that the same ratio applies to the 68 companies that did not answer the phone call but had a working phone number suggests that 63 of these companies are active in the geothermal business while 5 are not.

Concerning the 14 companies that could not be reached due to incorrect contact information, the conservative assumption is made that these companies are no longer active in the geothermal business.

The average number of employees per company yielded by the survey is 13.6. Should this average employment rate be applied to the 63 companies that are expected to be active in the geothermal sector, these companies would account for **858** additional jobs. Similar calculation for individuals accounts for **8** additional jobs[5].

B. Enhancing the CEC-GEO list response rate and estimating employment of companies that did not respond the survey.

In order to enhance the rate of response of the CEC-GEO list, phone calls were made to the 204 remaining companies in order to find out if they were still active in the geothermal field. If the company answered affirmatively, a second question asked for their current workforce involved in these activities. Since no other questions were asked during these phone calls, these responses only provided information about the number of companies currently involved in geothermal activities and their respective geothermal workforce. These results could thus not be included in the previous analysis.

Of the 204 companies that were contacted:
11% (22) responded that they are still active in geothermal activities,
25% (51) responded that they were not active in the geothermal business,
14% (29) could not be reached due to incorrect contact information, and
50 % (102) did not answer the phone call but had a working phone number.

These numbers suggest that 22 out of the 73 companies that responded to the phone call are actively working on geothermal issues and that 51 are not. In other words, 30% of the companies that responded to the phone call are active in the geothermal business while 70% are not. Among the companies that declared themselves to be active in the geothermal business, the average workforce appeared to be substantially lower than for the companies that responded to the entire survey questionnaire. Although it is characterized by an important variability, the average geothermal workforce for these 22 companies corresponds to 4.8 employees. This value was used for the subsequent calculations.

For the 102 companies that did not answer the call but had a workable phone number, it is assumed that the ratio of companies active in the geothermal sector vs. non active

[5] Out of the 44 individuals listed on the GRC-GEA list, 10 responded to be actively working on geothermal issues and 10 responded not to be active on geothermal issues. Since 8 had incorrect contact info and 16 had workable phone numbers but could not be reached, this suggests that 50 % of these 16 individuals are active in geothermal business.

obtained with the earlier responses is applicable. This suggests that another 31 companies are active in geothermal business while 71 are inactive.

Since it is also assumed that the companies that could not be reached due to incorrect contact information disappeared or merged with other companies, the expected employment impact of these companies is considered to be zero.

The above responses and assumptions result in estimates that 53 (22 + 31) companies were not included in the initial survey responses and that these 53 companies account for **256** geothermal jobs not captured in the initial survey.

C. Estimating subcontracted employment

The section of the survey dealing with subcontracted employment yielded limited responses. Only 12% of the responding companies provided information about subcontracted employment and most of this information displayed significant inconsistencies. Additionally, almost none of these responses provided the name of the subcontractor, which is needed to avoid possible double counting of this workforce if the company providing this subcontracted service already responded to the survey. Information provided by this section of the survey questionnaire was thus judged unreliable and could not be used for further analysis.

However, since power plant operators were suspected to use a significant subcontracted workforce, a detailed investigation of the structure and nature of employment involved in geothermal operations was completed with one of the major geothermal power producers. This study revealed that many activities related to power plant and well field operation and maintenance are subcontracted.

Further investigation showed that most companies involved in subcontracted activities did not appear on the directories used to disseminate the survey. Most subcontractors have indeed a specific field of activity that is not directly or exclusively related to geothermal power production but is essential to power plant or well field O&M. For example, subcontractors are active in drilling, truck & crane activities, cooling tower repair, power equipment overhaul, security services, etc. Most of these subcontractors could not be reached with the initial survey. Particular attention was paid to avoid double counting of this subcontracted workforce and specific analysis showed that only 12% of the workforce involved in subcontracted activities had already been captured in the survey responses.

Since the importance of subcontracted activities is directly related to the structure of the company, all other major power producers were asked to provide subcontracted employment numbers. This information is probably not applicable to most other type of companies of the geothermal sector but provided information about a significant workforce that could not be reached previously.

Subcontracted workforce typically represents 42% of the power plant operator's own workforce and 30% of total employment involved in power plant operation and maintenance (O&M). Responses provided by the major geothermal power producers revealed that, on average, total employment related to power plant O&M account for 0.74 jobs per MW. Of these, 0.52 jobs/MW is the power plant operator's own workforce and 0.22 jobs/MW is subcontracted employment.

Companies that responded to the survey account for 79% of total geothermal power capacity currently operating in the US and employ 1040 workers. Since 21% of the power capacity could not be captured, this suggests that, in the US, geothermal power producers directly employ 1317 workers[6].

As a result, subcontracted employment related to power plant operation and maintenance is expected to account for 553 additional jobs. However specific investigation showed that the initial survey captured 12% of these jobs through direct responses of companies providing such services. This suggests that the fraction of subcontracted employment involved in power plant operation and maintenance that could not be captured accounts for an additional **487 jobs**.

D. Employment estimates Conclusions:

The three previous sections suggest that total employment that could not be captured in the survey due to the absence of response of companies account for 1609 additional jobs:
866 (858 + 8) of these are related to the organizations of the GRC-GEA list,
256 are related to the companies of the CEC-GEO list, and
487 are related to subcontracted employment.

Since the survey captured 2642 jobs, these estimates suggest that a total of **4251** persons are currently working in the geothermal sector.

E. Estimates assumptions and limits:

The methodology and assumptions used during the above analysis induces limits and uncertainties that have to be kept in mind while considering the results presented in the previous sections. The following discussion broadens the spectrum of this analysis by raising some important issues and investigating the sensitivity of results to hypothesis changes.

1. Twenty organizations that did not appear on lists and directories used to send the survey provided employment data. Some of these records may be related to companies that have been contacted but responded using a different company name. However, a certain number of these responses are presumably from companies that were not listed. This suggests that all companies active in geothermal activities could not be reached, and

[6] This statement suggests that 277 employments out of the 858 estimated to be related to the companies of the GRC-GEA list that did not respond the survey are power producer's employees directly involved in power plant operation and maintenance.

that other organizations active in the geothermal business exist and account for additional employment. No further estimates could assess the size of this workforce since no information could be found about these companies. The above analysis thus ignores the workforce potentially involve in these companies. This adds to the conservative character of the above employment estimates.

2. Subcontracted employment estimates included in the above employment figure only consider subcontracted workforce involved in power production O&M activities. Although O&M is assumed to represent a major part of all subcontracted activities, a non-negligible workforce may have been ignored.

3. A final list of subcontractors and grantees from the California Energy Commission was obtained too late during the result analysis process and could thus not be used. It included 94 additional organizations not listed on the previous lists described, but contact information was often missing or incomplete. Sixty percent of these organizations were local government agencies. Although most of these organizations are thought to account for little additional geothermal employment[7], this workforce could not be included in the above analysis and employment figure.

The above three paragraphs suggest that assumptions considered in the previous sections are conservative and may give a low employment figure for the industry. The following paragraphs will thus consider another set of realistic although more favorable assumptions.

H1: Organizations that had incorrect contact information are treated like companies having a workable phone number for the calculations estimating employment related to companies that did not respond to the survey but appeared on the reference lists.

This hypothesis brings the number of companies assumed to be active in geothermal business to: - 82 for the GRC-GEA list, and
- 41 for the CEC-GEO list.

This hypothesis also brings the number of individuals of the GRC-GEA list involved in geothermal business to 12.

H2: Since employment figures of companies of the CEC-GEO list contacted by phone were very scattered and based on relatively few observations, this value may be truncated and it may be more appropriate to use the average employment value observed in the survey results (i.e. 13.8 employees per company). This value may be high since the largest companies were captured in the survey[8] but this hypothesis compensates for employment of organizations that could not be captured, reached and estimated with the survey (cf. assumptions limits 1, 2 & 3 explained above).

[7] Some organizations appearing on this list appear to be local administrations managing grants but not actively involved in geothermal activities.

[8] The survey results show that the average geothermal workforce of companies not owning and operating power plants is 8.8 jobs. Similarly, the average employment rate of all responses, except the top ten largest employers, corresponds to 5.5 jobs per response.

These hypotheses (H1 & H2) suggest that total employment in the geothermal industry that could not be captured with the survey may be closer to 2272 jobs[9]. When added to the 2642 jobs captured with the survey, this brings total employment involved in the geothermal industry to 4914 jobs.

[9] This value comes from the addition of: 1127 (i.e. 82*13.6 + 12) from the GRC-GEA list, 658 (i.e. 41*13.6 + 22*4.8) for the CEC-GEO list and 487 for subcontracted employment.

CONCLUSIONS.

The survey yielded 195 responses that accounted for 2642 geothermal jobs. Geothermal employment typically represents a small part of total employment for companies having activities outside the geothermal business. The survey results show that the average size of the geothermal workforce correspond to 13.8 jobs per company but a majority of the responses (65%) reported to have 5 or fewer employees involved in geothermal activities. Private companies constitute the largest category of respondents and, along with independents and consultants, account for over 71 percent of all responses and encompass close to 88 percent of total employment of the sector. An overwhelming majority of geothermal jobs (86%) are full time permanent positions. This value becomes 90 % for jobs related to private companies.

Two different sets of assumptions have been considered to estimate geothermal employment that could not be captured with the survey. The main analysis is a conservative estimate and provides a number of 1609 additional jobs. More optimistic hypotheses outlined in section 3-E *"Estimates assumptions and limits"* suggest 2272 additional jobs. As a result, employment involved in the geothermal sector is in the range of 4251 to 4914 jobs. The intermediary value of 4583 jobs is considered as the most appropriate employment figure. Should this figure be related to the total existing geothermal power capacity, the average employment ratio for the entire industry would correspond to 1.7 jobs per MW. Methodological approximations, biases and other uncertainties should however allow for a 7 to 10% range of variability around this value.

Status of the Industry in 2004

Employment captured in this survey reflects the status of the industry in 2004. This means that, although the level of activity is rising rapidly among geothermal developers and that an increasing number of new projects are under investigation, only one new power plant has been brought on line during the last 12 years. As a result, the current geothermal workforce focuses on operation and maintenance of existing power facilities, and the network of suppliers typically involved in power plant construction and equipment manufacturing has virtually disappeared. Accordingly, the survey could not capture or estimate employment related to power plant construction or power equipment manufacturing. Since acute competition in the energy sector along with technological evolution forced companies to adopt more efficient business practices and reduced their workforce when possible, it is GEA's view that geothermal employment is currently at a minimum.

Should the industry recover a steady growth rate, employment impacts related to power plant construction and equipment manufacturing would significantly contribute to socioeconomic benefits of new geothermal power facilities[10]. Environmental Impact Studies (EIS) of new power projects provide information about employment directly

[10] Except for a couple of components like the turbine, most power plant components are or could easily be produced by companies located in the U.S.

involved in power plant construction. This information is presented in the following sections with employment impact estimates for power plant equipment manufacturing activities. This information has been put together with the geothermal industry growth projections of the Energy Information Administration (EIA) in order to estimate total employment impacts of future industry growth.

Additionally, since most articles dealing with employment involved in renewable energy technologies make a clear distinction between direct and indirect employment impacts, the final section presents similar figures for the geothermal industry.

Comparing results with the previous employment survey.

When the results obtained by this survey are compared with those from the previous survey completed in 1978, a couple of interesting facts may be highlighted.

Although the power generation capacity of the industry has more than quadrupled, the overall size of the geothermal workforce has only increased slightly. In 1978, Hannah (1981) estimated that 3340 full time equivalent persons were working on geothermal issues. For that same year, the Energy Information Administration states that total geothermal power generation capacity was 608 MW.

Although the overall workforce has only slightly increased, the distribution of employment among the various kinds of activities has changed significantly. Systematic comparisons between the studies are not possible due to differences in methodology and level of detail of study detail. However, it appears clear that research and other development activities such as resource exploration and assessment constituted an extremely large share of total geothermal employment in 1978. Government support was also much larger and government employment involved in geothermal projects was 2.5 times larger. Research activities accounted for 26% of geothermal workforce and power plant construction for 9%. Today, employment related to research institutions account for 3.5% of geothermal employment. Similarly, labor involved in power plant construction has shrunk significantly as few projects are currently being built.

Technology improvement and efficiency gains also reduced the number of operators needed to run power plants. Various kinds of activities became subcontracted tasks as power producers faced increased competition and managed to cut off direct employment costs and focused on their core business.

However, some similarities still exist. The sector is still made of a couple of large companies that account for most of the geothermal workforce. A large majority of the organizations involved in geothermal business are private companies and most of them have fewer than 5 employees.

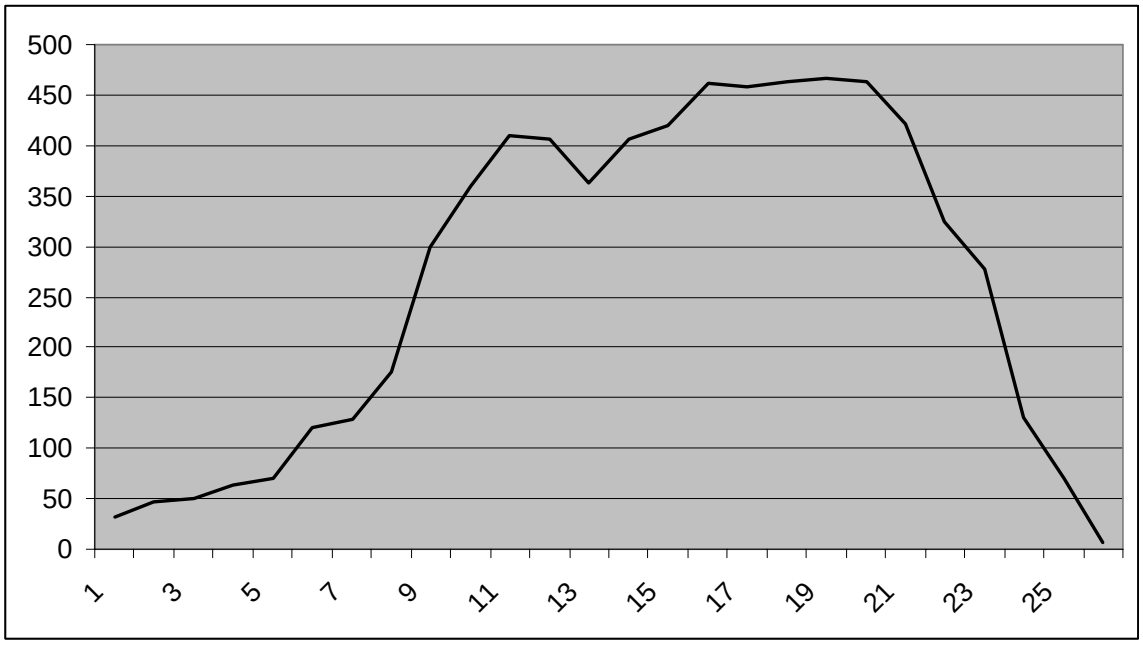
POTENTIAL EMPLOYMENT IMPACT OF FUTURE INDUSTRY GROWTH

Employment related to power plant construction.

Building a new power plant typically takes about 17 to 33 months. Since the type of construction activities changes throughout the project completion, the type of workers involved in these tasks also evolves. In order to adequately characterize construction employment it is thus important to consider its temporary nature. Construction employment is therefore expressed in "person*month" (P*M) or "person*year" (P*Y) units. One P*M corresponds to the workforce of one person working during one month. Similarly, one P*Y correspond to the employment of one person during one year.

Most information dealing with construction employment is provided in Environmental Impact Studies (EIS) of new geothermal power projects. However, these documents tend to provide only the peak number of employee as well as the total length of the construction period. The EIS of the Salton Sea Unit 6 to be built in the Imperial Valley however provides the distribution of the different kinds of workers throughout the construction period. In this document total workforce required to build a new 185 MW geothermal power plant is estimated to be 6898 person*month. Figure 1 presents the distribution of this workforce throughout the entire construction period is shown below:

Figure 1: Distribution of construction employment throughout construction period.



Source: CalEnergy, *"Salton Sea Geothermal Unit #6 Power Project - EIS & EIR "*, July 2002.

Of the 6898 person*month involved in this construction, 6247 are involved in power plant construction and 651 will build the power transmission line. This number of 6898 P*M suggests that the construction of a geothermal power plant requires 37.4 P*M per MW or 3.1 person*year per MW of power capacity installed.

The numbers presented above are consistent with other construction numbers that could be obtained from various EIS and geothermal developers. Some smaller projects may however present slightly lower number of workers per MW. A construction workforce of 3.1 person*year per MW installed (including well drilling) is thus considered in the following analysis.

Employment related to power plant equipment manufacturing.

The "Renewable Energy Policy Project" recently estimated manufacturing employment related to geothermal power plant equipment production. These estimates suggest that manufacturing of power plant equipment involves 3.3 jobs per MW for both flash and binary plant power facilities.

Projections of industry growth.

In its *Annual Energy Outlook 2005* report, the Energy Information Administration considers that the geothermal power sector will show an average 3.5% annual growth rate for the next 20 years. In addition to this base case scenario it also estimates that a conservative estimate would correspond to a 3% average annual growth rate while a more optimistic growth rate value would be 5.7%. The actual number of megawatt (MW) expected to come online during the upcoming years is displayed in the following table.

Table 6: New Geothermal Capacity to be brought on line (MW)

Year	*Reference Case*	*Low Technology case*[11]	*High Technology Case*
2005	*76 (MW)*	*65 (MW)*	*123 (MW)*
2006	*79*	*67*	*130*
2007	*81*	*69*	*137*
2008	*84*	*71*	*145*
2009	*87*	*73*	*153*
2010	*90*	*75*	*162*
2011	*93*	*78*	*171*
2012	*97*	*80*	*181*
2013	*100*	*82*	*191*
2014	*104*	*85*	*202*
2015	*107*	*87*	*214*
2016	*111*	*90*	*226*
2017	*115*	*93*	*238*
2018	*119*	*96*	*252*
2019	*123*	*98*	*266*
2020	*127*	*101*	*281*
2021	*132*	*104*	*297*
2022	*136*	*108*	*314*
2023	*141*	*111*	*332*
2024	*146*	*114*	*351*
2025	*151*	*118*	*371*
2026	*156*	*121*	*392*

[11] The Low Technology Cases (vs. High Technology Case) correspond to a less (vs. more) favorable evolution of the geothermal power technologies and/or market conditions.

According to the employment numbers related to power plant construction and equipment manufacturing, the projections of Table 7 suggest that further grow of the geothermal power capacity will spur the creation of lots of new jobs. The following table estimates the total number of jobs created by to the annual capacity increase corresponding to EIA's reference case for geothermal industry growth.

Table 7: Employment impact of geothermal industry growth (reference case).

Year	New MW installed	Manufacturing Jobs	Construction Jobs	O&M Jobs	Total Annual Employment Impact
2005	76	251	236	56	543
2006	79	261	245	115	620
2007	81	267	251	175	693
2008	84	277	260	237	774
2009	87	287	270	301	858
2010	90	297	279	368	944
2011	93	307	288	437	1032
2012	97	320	301	508	1129
2013	100	330	310	582	1222
2014	104	343	322	659	1325
2015	107	353	332	739	1423
2016	111	366	344	821	1531
2017	115	380	357	906	1642
2018	119	393	369	994	1755
2019	123	406	381	1085	1872
2020	127	419	394	1179	1992
2021	132	436	409	1277	2121
2022	136	449	422	1377	2248
2023	141	465	437	1481	2384
2024	146	482	453	1590	2524
2025	151	498	468	1701	2668
2026	156	515	484	1817	2815
Total	**2455**	**8102**	**7611**	**18403**	**34115**

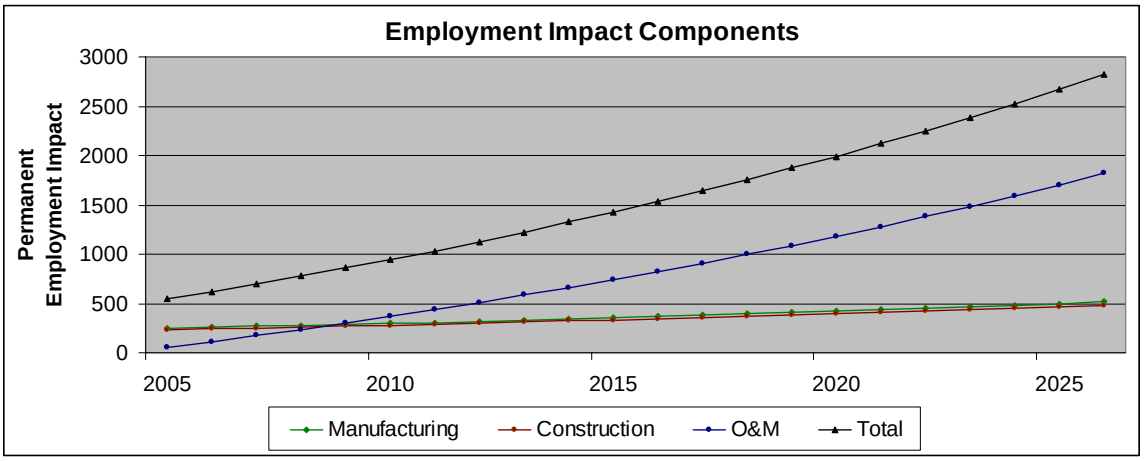
This table suggests that an average 3.5 % growth rate during the next 20 years will create 34,115 jobs. In order to reflect the temporary aspect of manufacturing and construction employment, this tables uses a person*year employment unit.

Since operation and maintenance of geothermal power facilities are permanent jobs, it is interesting to analyze the results of the above table and express them as long-term permanent employment impacts. Manufacturing and construction employment is indeed temporary and strictly related to industry growth[12]. The actual number of new permanent employment created annually by both these activities is thus much lower than for O&M activities and, in 2026, O&M employment makes up over half of the resulting

[12] Employment involved in manufacturing activities related to power plant O&M (equipment replacement and repair) was not estimated in this section and is considered as indirect employment.

employment impact. The following chart summarizes the actual permanent employment impact of the geothermal industry growth corresponding to the reference case.

Figure 2: Long-Term Permanent Employment impact of industry growth.



As a result, 2815 full time permanent employments will be created over the next twenty years if the industry grows in accordance with the EIA's reference case projections. Should this value be expressed in the person*years employment unit, this corresponds to 34,115 jobs.

Similar employment impact estimates for EIA's low technology and high technology scenarios are presented in appendix C. These calculations suggest that the lower growth rate projection would create 27,867 person*year or 2244 full time permanent employment over the next 20 years. At the opposite, the high technology growth rate scenario suggests that 68238 person*year jobs or 6304 permanent employment would be generated by the next 20 years of geothermal development.

As a conclusion, further development of the industry is expected to generate significant increase of the current workforce involved in geothermal activities. The reference scenario suggests that an additional 2815 long term positions will be created in the geothermal industry within the next 20 years. This corresponds to a 61% increase compared to the current geothermal workforce. A distinction should however be made between manufacturing and construction (M&C) employment and operation and maintenance (O&M) jobs. Today, few employments are related to manufacturing activities while 1804 workers[13] are involved in O&M labor. Within the next 20 years, total workforce involved in O&M activities is expected to double, and 999 new jobs will be created in M&C. Since O&M jobs typically last for the entire lifetime of the power plant, while M&C directly depend on the annual growth rate of the industry, two thirds of the jobs created are long-term, stable and high value jobs. It is also important to keep in mind that all activities outside power plant M&C and O&M were kept out of these projections but account for 61% of current geothermal employment. Further growth of the industry is also expected to spur additional job creation in this part of the industry.

[13] This 1804 value comes from the sum of 1317 power plant O&M workers directly working for power producing companies and 487 workers involved in subcontracted O&M activities (see p. 10).

The 1.7 jobs per MW ratio obtained in the prior section thus suggest that a 2455 MW power capacity increase will have a general employment impact corresponding to the creation of 4173 permanent jobs. This figure excludes manufacturing and construction jobs.

EMPLOYER MULTIPLIERS: INDIRECT & INDUCED ECONOMIC IMPACTS

This section provides estimates of the indirect and induced impacts of power projects on the local, state and nation's economy. These impacts are important to consider since any investment in a particular sector of the economy will impact other sectors. It is thus important to be able to assess the global impacts of such investments on the economy.

Indirect and induced impacts are calculated with "Input-Output Models" that provides a comprehensive picture of the economy considered. An I-O model consists of a system of linear equations, each one of which describes the distribution of the product of an industry throughout the economy (Miller & Blair, 1985). Each of these industries both produces goods and services (outputs) while simultaneously consuming goods and services from other industries (inputs). The model (system of linear equations) describes the economic relationship and linkages between industrial sectors and quantifies the impact of investments in specific industries on other industrial sectors. Such models thus provide a far-reaching picture of the economy as a whole and captures employment multipliers effects, as well as macroeconomic impacts of shifts between sectors (i.e. they account for losses in one sector (e.g. coal mining) created by the growth of another sector (e.g. geothermal industry)).

Input-Output Model distinguishes three kind of economic impacts:

Direct impacts relate to all expenditures associated with construction and maintenance of geothermal power plants. During the construction phase, it corresponds to the total investment associated with the power plant construction. During the operation and maintenance phase, it relates to all expenditures in goods and services associated with power plant operation and maintenance.

Indirect impacts correspond to the economic impact that affects all industries that provides goods and services to the industries directly involved in power plant construction or operation and maintenance. Indirect impacts thus quantify the impact of changes in power plant construction or O&M activities on the industries that supplies it.

Induced impacts; Industries that experience both direct and indirect impacts will often change their employment levels to meet the new level of demand. These employment changes induce changes in income that are spent in the region to purchase goods and services. This income effect is the source of induced impacts. Induced impacts leads to further rounds of indirect and induced impacts as the increased demand for goods and services purchased by workers leads to further increases in output in other industries[14].

Multipliers may thus be calculated to characterize the relation between direct and indirect and induced impacts. Indirect impacts resulting from a construction investment are however dependant on the size and characteristics of the economy considered. Local economy multipliers are therefore typically smaller than state or nationwide multipliers.

[14] Extract from: *"Estimating the economic impact of geothermal resource development"*, Lesser (1994).

Similarly, wages paid to O&M workers have a different impact on the economy than construction investments. The following table therefore makes a clear distinction between the various multipliers found in the literature. Although I-O models allow to estimate indirect and induced economic impacts separately, few articles provide such details and the following table presents aggregated indirect and induced multiplier values.

Table 8: Economic Impact Multipliers for Geothermal Power Project Investments.

Author	Economy Size	Type of Expenditure		
		Non-Specified	Construction	O&M
Riddel & Schwer (2003/2004)	Nevada *REMI Model*	1.72		
Gallo (2002)	4 counties (CA)		1.61	1.74
Meidav & Pigott (1994) *quoting Miller (1994)*	California USA	2.0-2.1 2.5		
Sifford & Beale (1991)	1 county (OR)	1.2		
Flavinger (1989)	Nevada		1.74	1.3

Note: Further information about these multiplier values is provided in Appendix D.

Table 8 suggests that an average multiplier value for an economy of the size of Nevada is 1.7. It also advocates that this value would be slightly higher than 2 for the economy of California and becomes 2.5 for the entire US economy.

The actual meaning of these multipliers is that any dollar invested in a geothermal project in Nevada will induce a total output grow of Nevada's economy of $1.7 and $2.5 for the US economy. Accordingly, a geothermal investment of $280 millions (e.g. a 100 MW[15]) would result in a growth of output of $476 millions for Nevada's economy and to an output growth of $700 millions for the entire US economy.

Converting these indirect and induced economic impacts in indirect and induced employment impacts is however difficult since each sector of the economy is characterized by a specific labor intensity (i.e. amount of employees needed to produce a specific value of output). Two different approaches exist in the literature.

The first approach considers that the economic value of the indirect and induced impact may be converted in a number of jobs created, based on the sectors of the economy that benefit for these increased consumption. Sifford & Beale (1991) use this methodology and consider that 1 million dollar spend on household expenditure creates 12 jobs However, $1 million expenditures on public services would create 17 jobs that same amount spent on education would create 23 jobs.

Since the US economy accounts for 140 million workers[16] and produces a global output worth $11,735 billions (2004 US GDP[17]), the average output per worker correspond to $83,766. Reversing this relationship suggest that spending $83,766 would create 1 job.

[15] Assuming that average capital investment of a geothermal project corresponds to $2800/kW.
[16] Source: www.bls.gov
[17] Source: www.bea.doc.gov

Similarly, spending $1 million corresponds to 12 jobs. This approach suggests that the construction of 1MW of additional geothermal power production capacity would result in 24 jobs in Nevada and 50 jobs in the US[18]. These values are also consistent with employment multiplier values provided by Flavinger (1989).

Sifford & Beale (1991) also applied these multipliers to the amount of royalties and taxes paid by geothermal power producers to local authorities. According to this article, a 100 MW power facility would pay about $5 million taxes and royalties annually to the County (property taxes: 4.2 M$ + County Royalty Share (50%): 0.8 M$). Considering that 67% of that money is spent on education and 33% on other services, they estimate that royalties and taxes result in an additional 77 educational and 28 service jobs[19].

The second approach consists of applying the economic (output) multiplier to the direct employment values[20] in order to obtain indirect and induced employment impacts. This appears to be the methodology followed by Lesser (1993). The use of this methodology would significantly lower the number of indirect and induced value since direct employment created by the development of 1 MW of geothermal power capacity correspond to 7.14 jobs (i.e. 3.3 manufacturing jobs, 3.1 construction jobs and 0.74 O&M jobs). As a result, each new MW to be installed would generate 5 additional indirect and induced jobs in an economy of the size of Nevada, 7.5 additional jobs in an economy of the size of California and 10.7 additional jobs nation's wide.

Conclusions

Articles dealing with employment multipliers tend to use very different approaches and do not mention if the resulting employment impact is permanent or temporary. The second methodology presented here-above is certainly more conservative but probably more realistic than the first one that provides very large employment figures and probably overestimate indirect and induced employment impacts. Further investigation of this issue is behind the scoop of this study and the choice of the most appropriate multiplier, within a particular context, is thus left to the reader.

[18] Building a 1 MW plant correspond to a $2,800,000 investment that results in 4.76 M$ output in Nevada's economy and 7 M$ output nation's wide. Subtracting the initial direct investment, this suggests that indirect and induced impact corresponds to 1.96 M$ (NV) and 4.2 M$ (US). Considering a job creation rate of 12 jobs per million dollar spent, this correspond to 24 and 50 jobs created in Nevada and the US respectively.

[19] Since Sifford & Beale (1991) also estimate multipliers for "education" and "other services" to be respectively 1.89 and 1.63, this brings the total (direct, indirect and induced) local economic impact of taxes and royalties to 6.3 + 2.7 = 9 M$

[20] *"Direct employment includes jobs created in the manufacturing, delivery, construction/installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration"* (Kammen, 2004)

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Appendix A: Distribution of employment according to the kind of organization and the position characteristics.

Table: Distribution of Employment among the various types of organizations considered:

(# of employees)	Total	FTP	PTP	FTT	PTT
Private Company	2123	1904	172	18	41
Independent / Consultant	190	121	26	12	46
Government Agency	187	158	29	3	7
Research Institutions	93	66	14	11	4
Non Profit Association	22	9	4	8	2
Other	27	16	11	0	0
TOTAL	**2642**	**2274**	**256**	**52**	**100**

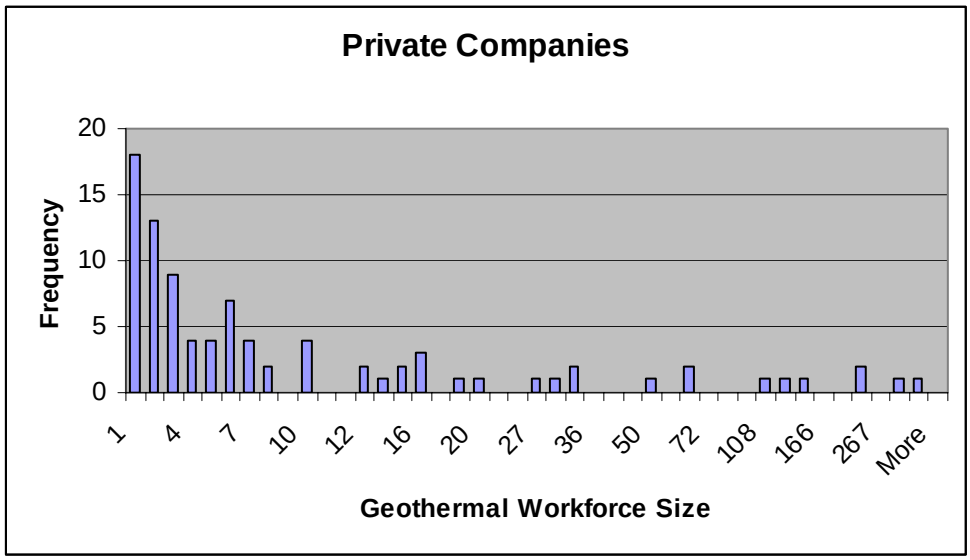
(Percentages)	Total	FTP	PTP	FTT	PTT
Private Company	0.80	0.84	0.67	0.35	0.41
Independent / Consultant	0.07	0.05	0.10	0.23	0.46
Government Agency	0.07	0.07	0.11	0.06	0.07
Research Institutions	0.04	0.03	0.05	0.21	0.04
Non Profit Association	0.01	0.00	0.02	0.15	0.02
Other	0.01	0.01	0.04	0.00	0.00

Legend:
FTP: Full Time Permanent employment
PTP: Part Time Permanent employment
FTT: Full Time Temporary employment
PTT: Part Time Temporary employment

Appendix B: Size and Frequency of the Geothermal Workforce.

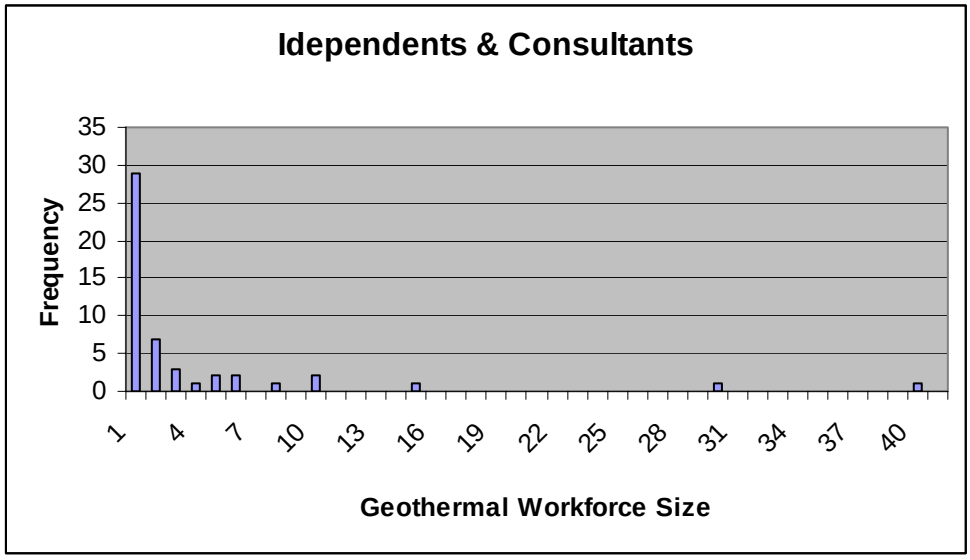
Private Companies and Independent & Consultant organizations encompass both the largest number of responses and an overwhelming majority of the workforce involved in geothermal activities. Distribution of their workforce size according to the frequency of responses is provided hereunder.

Figure B-1: Size and Frequency of Geothermal Workforce involved in Private Companies



Note: Abscise scale becomes exponential after the 10 value (exponent equals 1.03)

Figure B-2: Size and Frequency of Geothermal Workforce involved with Independent and Consultancy organizations.



Appendix C:

Employment Impact related to further industry growth:

Table C-1 : Components of the Employment Impact: EIA's Low Tech. Scenario

Year	New MW installed	Manufacturing Jobs	Construction Jobs	O&M Jobs	Total Annual Employment Impact
2005	*65*	215	202	48	464
2006	*67*	221	208	98	526
2007	*69*	228	214	149	590
2008	*71*	234	220	201	656
2009	*73*	241	226	255	723
2010	*75*	248	233	311	791
2011	*78*	257	242	369	868
2012	*80*	264	248	428	940
2013	*82*	271	254	488	1013
2014	*85*	281	264	551	1095
2015	*87*	287	270	616	1172
2016	*90*	297	279	682	1258
2017	*93*	307	288	751	1346
2018	*96*	317	298	822	1437
2019	*98*	323	304	895	1522
2020	*101*	333	313	969	1616
2021	*104*	343	322	1046	1712
2022	*108*	356	335	1126	1817
2023	*111*	366	344	1208	1919
2024	*114*	376	353	1293	2022
2025	*118*	389	366	1380	2135
2026	*121*	399	375	1470	2244
Total	**1988**	**6554**	**6157**	**15157**	**27867**

Figure C-1: Components of the Employment Impact: EIA's Low Tech. Scenario

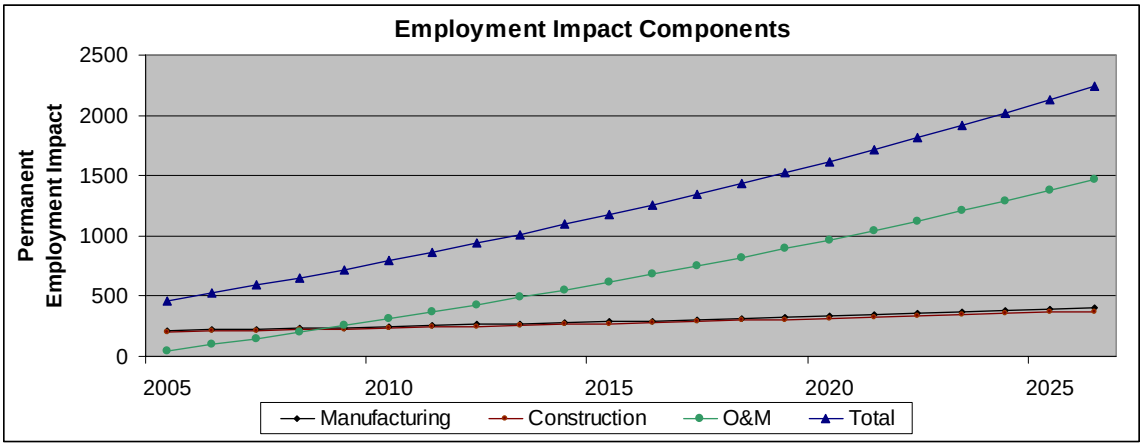
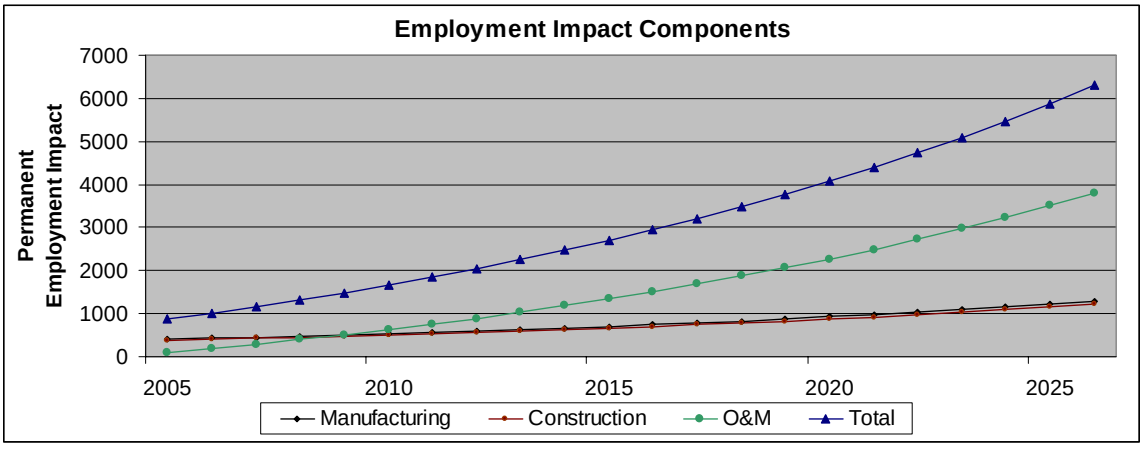


Table C-2: Components of the Employment Impact: EIA's High Tech. Scenario

Year	New MW Installed	Manufacturing Jobs	Construction Jobs	O&M Jobs	Total Annual Employment Impact
2005	123	406	381	91	878
2006	130	429	403	187	1019
2007	137	452	425	289	1165
2008	145	479	450	396	1324
2009	153	505	474	509	1488
2010	162	535	502	629	1666
2011	171	564	530	756	1850
2012	181	597	561	889	2048
2013	191	630	592	1031	2253
2014	202	667	626	1180	2473
2015	214	706	663	1339	2708
2016	226	746	701	1506	2952
2017	238	785	738	1682	3205
2018	252	832	781	1869	3481
2019	266	878	825	2065	3768
2020	281	927	871	2273	4072
2021	297	980	921	2493	4394
2022	314	1036	973	2725	4735
2023	332	1096	1029	2971	5096
2024	351	1158	1088	3231	5477
2025	371	1224	1150	3505	5880
2026	392	1294	1215	3795	6304
Total	**5131**	**16926**	**15900**	**35412**	**68238**

Figure C-2: Permanent employment impact: EIA's High Tech. Scenario



Appendix D:

Economic and Employment Multipliers: A Literature review

1. Flavinger (1989) used the RIMS II Input-Output Model to estimate economic and employment impacts of potential future geothermal development in Nevada. He defines "capital investment in geothermal power plants" as "final demand in construction of new utility facilities". The multiplier figures developed in RIMS II can be used to estimate the indirect effects induced by the change in demand:

	"Output" multiplier	"employment" multiplier
Construction	1.74	27.9
O&M	1.3	7.8

2. Lesser (1993) Charts provided at the end of his article allow to estimate the relationship between direct construction jobs (~460 jobs) and total employment impact generated by the project (~775 jobs) correspond to a ratio of 1.68. This value is assumed to be the economic multiplier effect obtained with the Input-Output Model.

3. Meidav & Pigott (1994) refer to personal communications with S. Miller of the California Energy Commission to claim that: "*The California Energy Commission estimates that the appropriate multiplier factor to estimate the Gross State Product (i.e. the multiplier factor as applied to impact on the California economy only, resulting from geothermal power development) is between 2.0 and 2.1 as compared to the 2.5 factor which is employed in estimating the impact on the nation economy"* (Miller, 1994). This means that every dollar invested in geothermal power production has a total economic multiplier effect on the US economy of about 2.5 times the actual amount spent in developing the geothermal project itself.

4. Gallo (2002) estimates the total economic impact of the Telephone Flat and Fourmile Hill projects at the Medecin Lake area. The Input-Output Model he uses encompass 4 counties: Siskiyou, Modoc, Shasta in California and Klamath County in Oregon. Economic impacts estimates include the effects on regional income and local tax revenue. In this analysis, the value of the construction and O&M multipliers are respectively 1.61 and 1.74.

5. Sifford & Beale (1991) use the IMPLAN model to estimate the total local economic impact of future geothermal development in Haney County, Oregon. In this study, the authors make a clear distinction between the multiplier effects of various kinds of expenditures. Multipliers and job creation impacts are presented in the table below:

	Multiplier	Jobs created per $millions spent
Household expenditures:	1.25	12
Education services:	1.89	23
Other services:	1.63	17

Appendix E: Survey Questionnaire:

GEOTHERMAL EMPLOYMENT SURVEY

This short questionnaire seeks to collect current data concerning employment in the geothermal industry. The results will provide better information about one of the most important socio-economic benefits of the geothermal sector.

Collected data will be processed with the highest **confidentiality** and individual responses to this survey will not be shared with other organizations or individuals. **This questionnaire is intended for US organizations directly or indirectly involved in the geothermal sector**. This survey should take about 5 minutes to be complete. For your ease, this survey is also available on line on GEA's website: http://www.geo-energy.org/Survey.asp.

Please direct any questions or comments to Nathanael Hance at the Geothermal Energy Association: Phone: (202) 454-4251 or Email: nh@geo-energy.org. Once filled in, you can either fax this document at (202) 454-5265 or mail it at: Nathanael Hance, Geothermal Energy Association, 209 Pennsylvania Avenue SE, Washington DC, 20003

A. COMPANY INFORMATION.

1. What is the name of your organization/company?

.....

2. Please provide contact information.

*Contact information is required to avoid double counting of companies. All information provided will be kept strictly **confidential.** The questionnaire cannot be processed without contact information.*

First name: ..... Last name: .....

Title: .....

Mailing address: .....

..... City / State / ZIP code

Email: .....

Tel: ..... Fax: .....

3. How would you best define your company/organization?

- ☐ Private company
- ☐ Government agency: Federal / State / Local (please circle)
- ☐ University, Research Institute or Laboratory
- ☐ Non profit organization
- ☐ Independent contractor or consultant
- ☐ Other: .....

4. Does your company have activities outside the geothermal industry? □ Yes □ No

If yes, what percentage of your business is devoted to geothermal energy?

□ less than 1% □ between 26 and 50%

□ between 1 and 5 % □ between 51 and 75%

□ between 5 and 25% □ between 76 and 100%

5. Is your organization/company owned by a parent company? □ Yes □ No

If so, please provide its name: .....

Please, do not include data concerning your parent company for the following questions.

6. Does your company own subsidiaries working in the geothermal sector? □ Yes □ No

If yes, according to your capacity to include employment data of your subsidiaries when responding to this survey, you can either chose one or a mix of the following options:

□ Subsidiaries having employees are included in data provided in this survey.

Please list subsidiaries included: ....

□ Subsidiaries having employees are not included in data provided in this survey.

Please list subsidiaries not included: ....

7. Does your company own geothermal power plants in the US? □ Yes □ No

If yes, What's the total installed net capacity of these power plants? ..... (MW)

What's the total annual electric output of these power plants? ..... (GWh)

8. Please check the geothermal activities your organization/company is working in:

List of Activities:

□ Electrical energy production

□ Non-electrical application (Space heating/Agriculture/etc.)

□ Research and Development

- □ Resource exploration and assessment
- □ Reservoir design and development
- □ Well drilling and drilling services
- □ Plant design and construction
- □ Steam gathering and transmission

□ Planning, Impact assessment and feasibility studies

□ Environment

□ Finance

□ Legal

□ Consulting
  - □ Resource exploration and assessment
  - □ Reservoir design and development
  - □ Well drilling and drilling services
  - □ Plant design and construction
  - □ Steam gathering and transmission
□ Construction
  - □ Well drilling and drilling services
  - □ Power Plant
  - □ Well field
  - □ Electric transmission
□ Operation and maintenance of power facilities
□ Leasing & Land administration
□ Governmental relations and regulations
□ Manufacturing /Sales
□ Education
□ Publishing
□ Supporting services (cleaning, mailing, back-office activities, etc.)
□ Other .....

B. EMPLOYMENT IN YOUR COMPANY.

For this section, please consider only full-time and part-time employees working either with permanent and temporary contracts[21]*. **Do not** consider services performed by contractors or consultants. The following questions refer to the year 2003. You may either use your company's fiscal year or the calendar year.*

1. How many employees did your organization/company have? .....
(Geothermal and all other activities considered together)

2. How many of these employees work in geothermal related activities? .....

3. Please indicate how many of the employees working in the geothermal activities are working with a :
- permanent full-time employment contract: .....
- permanent part-time employment contract: .....
- temporary full-time employment contract: .....
- temporary part-time employment contract: .....

[21] Permanent employments are characterized by open-ended contracts while Temporary workers have fixed term contracts.

C. EMPLOYMENT ASSOCIATED WITH SUB-CONTRACTORS OR CONSULTANTS.

This section aims to evaluate the workforce directly and indirectly involved in geothermal sector through sub-contracted activities. Directly related activities are kept separately from indirectly related activities to help identify companies involved in the geothermal sector and to avoid double counting of the workforce involved in this activities.

1. If your company/organization sub-contracts activities directly or indirectly related to the geothermal sector, please check or quote the kind of activities that are subcontracted:

A. Directly related activities:

- ☐ Research and Development
- ☐ Construction of power facilities
- ☐ Operation and maintenance of power facilities
- ☐ Wellfield drilling, operation and maintenance
- ☐ Consulting (type: ....., ...)
- ☐ Other: .....

For directly related activities, please provide the name of companies and the average manpower involved* in these subcontracted activities[1]:

Name of Company	Type of Activity	Average manpower involved* (hours)

[1] If your company has too many subcontractors, please indicate the most important 10%.

* The *average manpower involved* in subcontracted activities represents the average time spent by subcontracted workers to achieve subcontracted activities. This time should be counted in hours of work for the year 2003. Should you prefer to use another unit, please indicate is clearly.

B. Indirectly related activities:

- □ Consulting (Type: ..... , ... , ...)
- □ Finance / Accounting
- □ Legal
- □ Supporting services (Type : ..... , ...)
- □ Other: .....

2. Please estimate how many workers do these subcontracted activities involve?

For directly related activities : ..... (total hours of work in year 2003)

For indirectly related activities : ..... (total hours of work in year 2003)

3. Given the number provided for question 2, please estimate the equivalent number of full-time jobs the total subcontracted work would represent: .....

Note: 1 full-time equivalent equals 2000h/year (i.e. 50 weeks of 40 hours)

COMMENTS CONCERNING THE SURVEY.

Please feel free to add any comments you may have concerning this survey:

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The Geothermal Energy Association thanks you for your help