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THE IMPACT OF
GEOTHERMAL ENERGY DEVELOPMENT
ON EMPLOYMENT

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ABSTRACT

This report investigates the projected impact of geothermal energy development on the economy. More specifically, it examines the impact of geothermal energy development on the creation of new jobs both locally and nationally. The report examines the economic impact of both electrical and non-electrical development of geothermal energy. The latter mainly addresses the explosive growth of the geothermal heat pump.

Direct Impact Versus Total Impact

Any primary commercial activity reverberates in the economy through the secondary and tertiary activities generated by it. Some activities, such as trading, result in a relatively small impact on job creation. For example, the sale of foreign manufactured cars, or foreign-purchased fuel, has little impact on domestic job generation, even though the monetary value of the transactions may be substantial. On the other hand, jobs in manufacturing, especially those that involve primary industries, have a substantial impact on jobs in secondary and tertiary industries.

Primary industries, such as mining or agriculture, have secondary impacts on job generations in other industries. These include the manufacture of mining and agricultural equipment, transportation services and the like. A tertiary impact is generated by the additional housing, transportation, schools, roads, and city and county services that are required to support the economic activities in the primary and secondary industries.

Various methods have been developed to establish the economic and job-creation impacts of different industries. These generally entail the utilization of input-output models. Examples of such studies are embodied in the work by Sifford et al. (1993) of the State of Oregon, Sanford Miller (1994) of the California Energy Commission, and others.

Geothermal energy development can be classified as a primary industry. It entails the extraction of raw heat from the earth and its conversion into usable energy. There are two forms of utilization of geothermal energy: electric power generation and direct heat uses. In the case of power generation, high grade heat is employed to turn turbogenerators to create electricity. In the latter case, lower temperatures are utilized to displace other sources of energy for space heating applications such as office and home heating or green house operations, where the heat can be utilized directly, without conversion into electricity. This report deals with both forms of geothermal energy use. The multiplier effects for both forms of geothermal energy do not differ substantially from each other in either the construction or operation phases.

This report assesses the direct impact of business activity related to geothermal energy resource development and utilization, and estimates the total impact on the economy, when taking the secondary and tertiary impacts into account.

The contribution of export of geothermal technology and the resultant business activity stemming therefrom falls into a separate category, and is also discussed.

This report does not delve into the political issues which may affect the rate of development of geothermal power production or direct heat use deployment in the U.S., such as the impact of changing laws regarding air pollution, or competition from fossil or from other renewable energy resources. Many legislative and institutional factors affect the rate of development of geothermal energy, but are outside the scope of this report. These include federal or state imposition of taxes on global warming gases, utility considerations of instantaneous versus levelized costs of energy, the value of diversity of energy resources and other factors. Instead, this report utilizes projections by the Energy Information Administration (1991) and by the U.S. Department of Energy (1994).

The Multiplier Effect of Geothermal Power Development

It is estimated that every dollar invested in geothermal power production has a total economic multiplier effect on the U.S. economy of about 2.5 times the actual amount spent in developing the geothermal project itself. Thus, for every dollar spent directly on drilling, power plant purchase, power plant erection at the site, about 1.5 dollars additional are spent elsewhere, on items directly related to the power project. For example, the driller will have bought drilling bits from a supplier. The drilling bit manufacturer, in turn, bought steel to manufacture his bits. The steel company bought iron ore from
the mining company. All of the suppliers have utilized a certain number of vehicles-hours for transport which is directly chargeable to the bits or other goods provided to the drilling company, as well as some hours of plant-time to assemble the bits, etc. Economists have found that a multiplier factor of 2-4 is appropriate for estimating the total impact on the economy of operations in a primary industry.

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 national economy (Miller, 1994).

Geothermal Power Comparison with Other Power Sources

A geothermal power project is somewhat similar in terms of cost structure to that of a hydro project and is quite distinct from projects which depend upon fossil fuels. In the case of both hydro and geothermal, the capital costs of the project are relatively high, but the operating costs tend to be lower than those of most fossil fuel projects. This is because all or substantially all of the fuel for hydro and geothermal projects is provided from the start. Once the dam is constructed, there are relatively modest costs in maintaining the dam and in desilting the reservoir. In the case of geothermal, a sizable geothermal reservoir must be proven before the power plant is built. After that, it is necessary to drill make-up wells to replace those that decline in output over time. A typical cost of either a hydro or a geothermal plant is always more than $2,200 per kilowatt installed capacity, or more than twice the capital cost of natural-gas-fired power plants.

Fossil-fuel-fired power plants tend to have a capital cost structure that is considerably less than that of renewable power. For example, gas-based power projects can be constructed for less than $1,000 per kilowatt capacity. However, all fossil-fuel-based plants must continuously purchase fuel at a price that is generally not predictable far into the future. The general assumption is that fossil fuel prices are likely to escalate at a rate that is equal to, or slightly greater than the inflation rate, because of the growing scarcity of fossil fuel in an ever-expanding world population.

As a result, the long term levelized cost of power from renewable energy resources is likely to be the same as or less than that from fossil fuel resources, despite the substantial price advantage that some fossil fuel plants, such as natural gas-based power, enjoy in the early years.

The observation that renewable energy resources typically start out more expensively than fossil fuel-based power, but become less expensive than fossil fuels in the latter years, creates a certain advantage for the renewables. Being more capital intensive, renewables tend to generate an economic activity in the short term which has a far more positive impact on the economy than the fossil-fuel-based plants, in addition to the benefit that society enjoys from clean energy sources versus polluting fossil fuel sources.

Geothermal Power Development Scenario

At present, a total of about 2,760 megawatts of geothermal power is installed in the U.S. However, because of the decline in output of The Geysers field in California, we assume the effective installed capacity to be 2,100 megawatts. Both the DOE and the EIA estimate the installed capacity by 2010 to be in the range of 7,000 megawatts, which represents an annual growth rate of 7.8% (the compounded growth rate would be 7.3% per year if calculated from the 600 megawatts installed capacity in 1975, ending at 7,000 megawatts in 2010). Figure 1 shows the projection of geothermal power growth rate in the U.S. to the year 2010.

![Figure 1. Projected U.S. geothermal power plant capacity, 1995-2010, assuming an 7.8% annual rate of increase in plant capacity.](image)

Value of Past Investments and of the Generated Power

The total value of the effective installed capacity by mid-1994 is estimated to be 5.9 billion dollars. The value of the electricity that is currently generated is estimated at about one billion dollars per year, assuming a price for the electricity to be 6.5 cents per kilowatt hour.

Geothermal Power Development Costs

The cost of geothermal power development varies with the temperature of the resource. For geothermal projects in high temperature regions, where the resource temperature is higher than about 340°F, the simpler flash technology may be utilized. In those cases, the overall cost of a typical geothermal power project ranges from $2,200 to $4,000 per installed
Thus, in addition to the jobs due to manufacture and construction of geothermal plants and of drilling related activities, a permanent number of jobs are created for the plants that are being constructed. At its projected level of 7,000 megawatts in 2010, it is anticipated that about $525 million will be spent directly in the operation of those plants, with a direct employment impact of about 10,500 jobs. Add to that about 15,000 jobs that will be generated within the economy due to purchase of equipment, supplies and services for the

**Impact of Operation and Maintenance on Jobs**

Many geothermal plants tend to be structured in a modular fashion. The size of geothermal plants, in any initial development, tends to be around 30 megawatts or less. Review of past experience and discussion with experienced operators of projects in that size range indicates that $2.5 million in annual expenditures is a reasonable value for the O&M cost for a plant in that size category. This includes salaries to power plant and geothermal field personnel, cost of replacement of pumps, servicing of wells, makeup drilling or redrilling, and the like.

The above expenditure translates to about 2.9% of plant capital cost annually expended to operate and maintain the project. Some economies of scale will occur in larger projects, with the total annual expenditure decreasing to about 2.5% of capital cost. In the following analysis we utilize 2.7% of capital costs as being a reasonable average for both smaller and larger projects. This translates to a direct expenditure of $2.27 million per year for an average 30 megawatt plant, or about $75,000 per megawatt for the life of the project.

The “direct expenditure” in O&M is that which the owner of the geothermal project actually incurs. It does not include the multiplier effect of that expenditure. It is estimated that when the secondary and tertiary effects are taken into account, the total economic activity resulting from the O&M in the field would amount to an annual expenditure of about $188,000 per megawatt per year for the life of the project.

Assuming that a total of 7,000 megawatts of geothermal power will be in operation by 2010, of which 4,900 will be added between 1994 and 2010, the economic activity due to direct investment will amount to about $14 billion. However, when the impacts of the secondary and tertiary effects are included, the total impact on the U.S. economy increases to about $34 billion, conservatively estimated. This latter value would amount to about 680,000 person-years over that time span, exclusive of manpower involved in operation and maintenance of the projects.

Figure 2 shows the incremental annual employment each year to 2010, due to geothermal power projects constructed in that year. Multiply the employment numbers by 2.5 to obtain an estimate of the total jobs created in the U.S. economy.

**Capital Cost and Employment Generation**

We assume that the $2,800 per installed kilowatt value takes into account both the higher cost of binary plants (or plants developed in the hyper-brines of the Salton Sea field) as well as the lower cost of flash plants developed elsewhere. Thus, a 30 megawatt project would require an average investment of $84 million.

In this report, a median value of $2,800 per installed kilowatt in 1994 dollars is employed for all geothermal plants.

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In the following analysis, we have taken the average cost of the technicians, operators and skilled laborers who develop, construct, and supply materials for a geothermal power plant at $50,000 per year, which includes their overhead.

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maintenance of the projects, for a total of 25,500 jobs. These jobs will continue for the life of the project. Assuming a 30 year life, the 7,000 megawatts will generate a total of 765,000 person-years over that time.

Figure 3 shows the projections of annual employment to operate and maintain (O&M) geothermal plants, 1994-2010. The annual employment figures must be multiplied by 2.5 to obtain a conservative estimate of the impact of O&M on the total economy.

The Geothermal Heat Pump

At a depth of a few tens of feet below the surface, the temperature of the soil or the rocks is equal to the mean annual temperature of the region. This means that by drilling holes just feet below the surface, or by laying a pipe grid in a shallow trench, it is possible to enter a temperature zone that is either unaffected by seasonal variations (40 feet or deeper) or is affected less than it would be at the surface. As a result, it is possible to provide space heating in winter and space cooling in the summer by tapping the shallow constant or near-constant temperature of the soil underneath. The geothermal heat pump utilizes that principle.

Geothermal heat pump (GHP) installations are growing rapidly. It is estimated that nearly 150,000 GHPs are already installed in the U.S. The popularity of the GHPs in Canada resulted in annual growth rate of geothermal heat pump installations that has exceeded 50% annually since 1986. The number of heat pumps that will be installed in the U.S. by the year 2010 is estimated to reach 3.5 million. The displacement of electric heating with the GHP would cause a substantial savings in demand for electricity at peak hours which would be in the range of one to five kilowatts per unit.

It is estimated that there are 25 million homes in the U.S. that have central air conditioning without access to natural gas for heating. Addition of GHPs to existing or future installations, would result in a saving of 24,000 to 48,000 megawatts during peak summer demand and 48,000 to 96,000 during peak winter demand (EIA, 1991). In effect, the GHP would serve as a demand-side management tool, by shaving off peak load demand.

Assuming a growth rate of GHPs at 21.8% annually at an average cost of $5,000 each, the number of additional GHPs installed by the year 2010 would be about 3.5 million, at a total value of about $17.5 billion (1994 dollars). Figure 4 shows the anticipated growth rate in GHPs in the 1994-2010 time frame.

The total direct employment resulting from a vigorous development of the GHP would be about 350,000 person-years. The impact would be about 880,000 person-years or more, if the total economic impact, including the multiplier effect, were to be taken into account. Thus, it is likely that demand-side management, through vigorous development of the GHP, would cause the impact of direct-heat utilization to outstrip that of electric power installations in terms of impact on the economy by 2010.

The rate of acceptance of the GHP in the U.S. is already quite high, and is likely to grow even faster if certain conditions are met. The price of the individual installations is still quite high, generally around $7,000, and possibly as much as $9,000 per unit. This results in an estimated payback period of
states, is likely to increase the acceptability of geothermal energy as a significant energy resource amongst legislators and administrators in Washington. As a result, geothermal energy may no longer be viewed as a peculiar energy resource located only in a few Western states. This, in turn, may result in a greater openness towards the goal of significant development of geothermal energy of all types. If that happens, geothermal energy development could significantly help the U.S. to reduce its dependence on fossil fuels, as well as improve the quality of the environment.

This report does not deal with the possible impact of any major breakthroughs in technology which could further accelerate geothermal energy development beyond the projections made above. Additionally, such technologies as heat mining or substantially reduced drilling costs, could have significant impacts which are not taken into account in this study.

**The International Market**

During the past 12 months, U.S. geothermal companies have signed substantial contracts to develop geothermal power internationally. These contracts total about 2,000 megawatts to be developed within the next ten years. The overwhelming majority of those contracts are associated with projects in the Philippines and Indonesia. In the Philippines, the contracts are largely for the development of power plants, gathering systems and interconnection to the grid. The geothermal fields are generally being developed by the PNOC, the local electrical utility.

The total value of the projects is estimated at $5.6 billion, in 1994 currency. It is unknown what fraction of each project will be financed by U.S. companies. The impact on exports of U.S. goods and services will greatly depend on financing policies of the ExIm Bank and other U.S. government agencies.

These projects are largely of the build-own-transfer (BOT) variety. Much of the equipment needed for the construction of these projects is likely to be purchased in Japan and Southeast Asia. Senior personnel and technical staff, however, are likely to be Americans. The main benefit to the U.S. participants will stem from the net profit resulting from those projects. The U.S. employment generation aspect is likely to be modest.

It is estimated that another 4,000 to 5,000 megawatts in additional contracts with a value of about $13 billion for the construction phase will be signed up by U.S. companies before the turn of the decade, for projects that will be carried out before 2010.

**Summary**

Two types of geothermal energy utilization, power generation and direct heat use applications, will have their
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respective impacts on the economy. It is anticipated that
domestic geothermal plant capacity for electric power genera-
tion will grow from about 2,100 effective megawatts (i.e. from
the level of actual current geothermal power plant operation) in
1994 to about 7,000 megawatts by the year 2010. This reflects
a direct investment of about $14 billion. If we add the multi-
plier effect of 2.5, the total impact on the economy would
amount to about $34 billion over that time span. The total
number of jobs generated in the economy due to the primary
and secondary impacts of geothermal power development
would amount to at least 690,000 person-years over that time
span in the manufacturing sector (exclusive of manpower
involved in O&M).

Direct employment due to operation and maintenance
of the geothermal power projects will gradually grow over the
years, reaching about 10,500 permanent jobs in the year 2010.
Adding the secondary and tertiary impacts to that number, the
total employment due to O&M activities would amount to
about 25,500 jobs by 2010. The cumulative number of jobs as
a result of O&M would amount to about 765,000 person-years
over the life of the plants that are erected by 2010.

It is estimated that the geothermal projects developed
internationally by U.S. companies will result in additional
installed capacity which would be about equal in magnitude to
those installed in the U.S. However, we are unable to project
the impact on domestic employment as a result of the interna-
tional activities.

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