Socioeconomics and Geothermal Energy

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ABSTRACT

This papers addresses the socioeconomic aspects of geothermal electrical generation, including costs, economic impacts and contributions, and employment. Wherever possible, comparisons are provided between geothermal and other electricity sources.

Background and Introduction

In 2004, the Geothermal Energy Association (GEA), in support of the U.S. Department of Energy (DOE) Geothermal Technologies Program, surveyed the existing U.S. based geothermal literature related to socioeconomics. Much of this information turned out to be old, incomplete, or inconsistent. In response to these problems, GEA produced a series of publications on the socioeconomics of geothermal energy: *Factors Affecting Cost of Geothermal Power Development* and *Geothermal Industry Employment Survey Results and Analysis*, and is subsequently in the process of creating a white paper that addresses these and other aspects of the socioeconomics of geothermal energy. The paper that follows is a shorter version of GEA's socioeconomic white paper.

Socioeconomics, Geothermal Energy, and Sustainable Development

Socioeconomics looks not only at the short-term economic impact of development, but also at the social and environmental impacts of development over the long term. According to the International Institute for Sustainable Development (IISD), "for development to be sustainable it must integrate environmental stewardship, economic development and the well-being of all people—not just for today but for countless generations to come.[1]" Geothermal is one among a few industries that continues to provide economic, environmental, and community benefits over the long term.

Costs and Payments

Geothermal's upfront costs, made up of exploration, confirmation, and site development, comprise the majority of costs accrued over the life of the plant. In 2001, the Electric Power Research Institute (EPRI)[2] estimated that capital reimbursement and associated interest account for 65 percent of total cost of geothermal power, while the associated cost of fuel and operation account for only 35 percent. In contrast, fossil fuel-fired facilities typically spend 65 percent on fuel, and only 35 percent on upfront costs.[3] Since the cost of fuel at a geothermal plant is so low compared to the initial cost of planning for and building the plant, the operational cost is more likely to remain stable.

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[1] IISD. About. Retrieved April 6, 2006, from http://www.iisd.org/about/.

[2] G. Simons, *"California Renewable Technology Market and Benefits Assessment"*, EPRI, 2001.

[3] Capital cost of a combined cycle natural gas power plant only represents about 22 percent of the levelized cost of electricity produced from the plant whereas the fossil fuel cost accounts for 67 percent. (Source: "*An assessment of the economics of future electric power generation options and the implication for fusion*", Oak Ridge National Laboratory, 1999).

Exploration

The first step towards development, exploration, during which resources are sought, includes three phases. *Regional reconnaissance* identifies resource areas at the least specific level, at around 1000 km^2, while *district exploration* identifies resources within more precise regions of around 100 km^2. *Prospect evaluation*, the most costly and specific phase of exploration, seeks to locate the best sites to drill production wells with fluid temperatures and flow rates at levels that can produce electricity. The typical geothermal plant, a 50 MW facility, will cost $385,000 in total regional reconnaissance costs and $3.85 million in prospect evaluation costs.[4]

The U.S. Geological Survey's (USGS) 1978 geothermal regional reconnaissance exploratory survey, which considered mostly shallow resources, identified 125,000 MW of geothermal potential throughout the United States. Currently only 2700 MW is utilized—a mere fraction of the potential.

Geothermal and Oil and Gas Exploration: A Comparison

Because of technological constraints, geothermal resources below depths of 4 km are typically not considered economically viable. By improving technology and increasing the depth at which resources can be considered by only 2 km, to a total of 6 km, the potential for developable geothermal resources expands significantly. Though the drilling techniques and procedures for geothermal are similar to those used in the oil and gas industry, the latter is remarkably farther along in its exploration capabilities when compared to geothermal. The depth record for the Gulf of Mexico was 33,200 feet on January 2004 (Shell Oil.).[5]

Confirmation

The confirmation phase seeks to confirm the energy potential of a resource by drilling production wells and testing their flow rates until approximately 25 percent of the resource capacity needed by the project is confirmed. At a typical 50 MW geothermal facility, confirmation costs will total $7.5 million.

Site Development

The site development phase covers all the remaining activities that bring a power plant on line: drilling, project permitting, steam gathering system, and power plant design and construction. Site development costs at a 50 MW geothermal facility will total an average of $131 million.[6]

Although impacts are associated with any site development, fossil fuel site development tends to be much more destructive than geothermal. At coal facilities, for example, coal mining can disrupt large swaths of land. At oil facilities, fuel must be transported across considerable distances to be used at a plant. Geothermal development poses no potential for a disaster such as the Exxon Valdez disaster, where 15 million gallons of oil in transport were accidentally released into a pristine natural area. Besides lowering the potential for environmental disaster, geothermal use also lowers the expense to the economy. United States oil imports cost more than $65 billion a year.[7]

Drilling

The goal of drilling is to reach the top of the geothermal resource base, known as the production well. A typical, 50 MW plant would accrue $37.5 million in drilling costs.

Project Leasing and Permitting

Like all power projects, geothermal projects must comply with a series of legislative requirements related to environmental and construction issues. Permitting and leasing requirements tend to be more arduous, opaque, and uneven for geothermal than for many other types of electricity development projects. One estimate places an Environmental Impact Study (EIS) related to the National Environmental Protection Agency (NEPA) requirements at an average cost of $600,000, with an average time of up to two years.[8] However, most permitting costs vary significantly for each project, with smaller projects costing $200,000 and large projects costing over a million dollars over three years.

Steam Gathering System

The steam gathering system is the network of pipes connecting the power plant with production and injection wells. Benefits of injection include enhanced recovery of geothermal fluids, reduced subsidence, and safe disposal of geothermal fluids, not to mention the increased lifetime of the plant.[9] Geothermal plants, more than many others, require minimal outage rates for repair or upkeep of the steam system, which

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[4] All cost figures for "typical 50 MW plants" are drawn from: Hance, Nathanael (2005). *Factors Affecting Cost of Geothermal Power Development*. Geothermal Energy Association (GEA) and represent 2004$.

[5] Geothermal Energy Association (2004). *Geothermal Energy Potential.* Retrieved November 10, 2004, from http://www.geo-energy.org/USGeoProv.pdf.

[6] EIA's geothermal capital costs are low compared to those referenced in GEA's recent report, *Factors Affecting Cost of Geothermal Power Development* (see footnote 4). GEA lists geothermal development costs at $2620 per KW-hr, while EIA information represented in Table 1 of this paper lists geothermal capital costs at $2100 per KW-hr. The increase in the cost of the former can be explained because of the inclusion of additional cost parameters: financing, developer's soft costs, transmission costs, and others. Few of these parameters are included in the EIA figures of Table 1. EIA data is used in Table 1 because this information is consistent across technologies. If the figure of $2620 per KW-hr had been used for geothermal in Table 1, while using EIA figures for the other technologies, the cost figure for geothermal would include a larger set of parameters than those included in the other technologies, and thus would not provide a fair comparison.

[7] Pimentel, David, et al. (September 1994). *Renewable Energy: Economic and Environmental Issues*. BioScience; Vol. 44, No. 8.

[8] National Geothermal Collaborative (November 2004). *Geothermal Leasing Panel*. Accessed March 23, 2006, at http://www.geocollaborative.org/publications/default.htm.

[9] California Division of Oil, Gas, and Geothermal Resources (2004). *Geothermal Injection Wells*. Retrieved March 24, 2006, from http://www.consrv.ca.gov/DOG/geothermal/general_info/injection_wells.htm.

increases the reliability and long-term viability of the resource. At a typical 50 MW plant, the steam gathering system costs approximately $12.5 million.

Power Plant Design and Construction

In designing a power plant, developers must balance size and technology of plant materials with efficiency and cost effectiveness. Labor costs are estimated to account for 41 percent of total project costs while materials and "other" costs respectively represented the remaining 40 percent and 19 percent.[10]

Included in "other" costs are land costs. Geothermal power plants use less land and cause less degradation than many other fuel sources. Coal land use costs would be much higher if mining, transport, construction, and decommissioning were included. Nuclear costs increase due to the required safe maintenance of huge amounts of radioactive waste. Natural gas plants use hundreds of gallons of freshwater. Over 30 years, the period of time commonly used to compare life cycle impacts of different power sources, geothermal uses less land and freshwater than many other sources.[11] Geothermal plants can coexist with aquaculture operations, agricultural activities, and hunting activities.

The Production Tax Credit (PTC) and its Impact on Costs

The 2005 Energy Policy Act (EPACT) established a production tax credit (PTC) for several renewable technologies, including geothermal, in order to stimulate the production of renewable energy. According to industry experts and the GEA, the PTC is one of the most effective policy tools for expanding geothermal production. A report commissioned by the *Energy Foundation (EF)* cites that increasing renewable energy sources such as geothermal can "reduce natural gas prices, make energy bills more manageable, avoid costly disruptions to business and our daily lives, and put the American economy more firmly on the road to recovery."[12] Without the PTC, facilities could halt production of geothermal power, which would eliminate the associated benefits geothermal provides to local communities.

Mitigation Measures

Despite the minimal impact of geothermal facilities compared to fossil fuel sources, geothermal development usually includes extensive mitigation measures that help offset the impact of the power plant. Detailed site planning, facility design, materials selection, revegetation programs, and adjustment to transmission line routing are all key aspects of geothermal operations. Mitigation also consists of monitoring activities and implementation of noise muffling techniques and equipment.

Financing

Debt investors, who impose lower rates of returns than equity investors, usually will not lend money unless a certain percentage has already been invested by an equity investor. Today's geothermal projects are generally composed of 70 percent debt and 30 percent equity. But debt lenders (commercial banks) will require 25 percent of the resource capacity to be proven before lending any money. This means that all early phases of the project have to be financed by equity investors. As an added financial challenge, the levelized cost of power[13] produced by an Independent Power Producers (IPP)[14] is at least 44 percent more expensive than the levelized cost of a municipal utility. In the United States, all but one geothermal power producer is an IPP.

The True Capital Cost of Power: Considering Capacity Factor

At first glance, geothermal power plants seem to require higher upfront costs than most other renewable and fossil fuel technologies. A closer look, however, proves that this is not the case. The table below shows the weighted overnight costs once capacity factor (CF) is considered.[15] Capacity factor measures the amount of real time during which a facility is used. Geothermal plants have the highest projected rated capacity of any renewable facility according to EIA. The overnight or capital costs increase dramatically for most technologies when capacity factor is considered, but stay relatively stable for geothermal. This means that geothermal's overnight costs based on generation—the number of megawatts producing electricity—is competitive with other fuel sources. When an investment is made into geothermal, the electricity return is higher than for other technologies.

Longterm PPAs and Stability

Power purchase agreements (PPAs) typically last 10 to 20 years. Such agreements provide another mechanism through which geothermal provides stability to the electricity market. Any risk related to fuel is transferred from the market and/or consumer to the developer and/or operator. A PPA ensures a stable, long-term electricity price for decades.

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[10] Bloomquist, Geyer & Sifford (1989). *Innovative Design of New Geothermal Power Plants*.

[11] Brophy, Paul (1997). Environmental Advantages to the Utilization of Geothermal Energy. *Renewable Energy*, Vol 10:2/3, Table 3, pp. 374.

[12] American Council for an Energy-Efficient Economy (ACEEE) and Energy and Environmental Analysis, Inc., commissioned by the Energy Foundation (EF) (January 2005). Analysis *of Impacts of Energy Efficiency and Renewable Energy on Natural Gas Markets*. Retrieved April 5, 2006, from http://www.aceee.org/energy/efnatgas-study.htm.

[13] "Levelized cost" is defined as the total capital, fuel, and operating and maintenance costs associated with the plant over its lifetime divided by the estimated output in kWh over its lifetime (expressed here in current dollars).

[14] An "IPP" is a private entity that generates electricity and sells it to other businesses including utilities.

[15] From EIA (2006). *Assumptions to the Annual Energy Outlook 2006*. Retrieved April 17, 2006, from http://www.eia.doe.gov/oiaf/aeo/assumption/index.html.

Table 1. EIA Capital Costs Based on Electricity Generation.

Technology	Base Overnight Costs*	2010 Capacity Factor (percent)[16]	Weighted Overnight Costs+
MSW - Landfill Gas	1,443	90	1603.333
Biomass	1,659	83	1998.795
Wind	1,091	44	2479.545
Geothermal	2,100[17]	95	2210.526
Conventional Hydro	1,320	64	2062.5
Solar Thermal	2,589	31	8351.613
Photovoltaic	3,981	21	18,57.14

* = in 2005, per megawatt

\+ = In order to calculate the weighted overnight costs, we divided 100 by the projected 2010 capacity factor (CF) percent, and then multiplied the resulting number by the EIA listed base overnight cost. For example, to find geothermal weighted overnight cost, we divided 100 by 95, and then multiplied the resulting number (1.053) by 2,100.

O&M Costs

Operation and Maintenance (O&M) costs consist of all costs incurred during the operational phase of the power plant. Because geothermal relies on a constant source of free fuel, and because facilities operate under power purchase agreements that span 20 years with fixed rates *(see* Financing *for more information)*, geothermal resources are secure and available, with known, unchanging economic parameters. There is no uncertainty of overseas oil transportation or a fluctuating market. At an average 50 MW facility, O&M costs total a mere $1,000.

Payments (Government Taxes, Royalties and other Income)

Geothermal facilities contribute billions of dollars to the U.S. economy. Some of these contributions come as mandated royalties or taxes, while some come voluntarily from geothermal companies.

Royalties

Royalties are payments that power producers are required to make to the owners of the geothermal resource. By 1997, geothermal power plant operators had paid a total of nearly $500 million to the Federal Government in royalties.[18] In 2000, California alone supplied a record $14,373,308 in federal royalties from geothermal leases.

Taxes

Geothermal power producers contribute to government budgets through property, federal and state income, and sales taxes. Geothermal plants are among the largest taxpayers in almost every county where geothermal power plants exist. In 2003, The Geysers paid property taxes to two counties totaling more than $11 million. CalEnergy, the largest geothermal company in the region, is the single largest taxpayer in Imperial County, supplying 25 percent of the tax base.[19] At the power plants located in Inyo County, California, plant owners pay approximately $6 million annually, of which roughly two-thirds is used to fund schools.

Voluntary Payments

Besides the required royalty and tax payments, geothermal companies regularly provide voluntary funds to the communities in which they are located. The Mammoth Pacific power plant, for example, has been designated a "good neighbor" by many locals, including Dan Lyster, Mono County Economic Development Director, for making donations to local groups in the area and building a new community center from the proceeds of the power plant.

Projected Tax Payments

The moderate 2001 goals of the DOE Geothermal Energy Strategic Plan could result in payment of over $7 billion in royalties to the Federal Government by 2050, and income tax revenues of over $52 billion. From just the state share in these royalties, alone, that would mean an additional investment of $3.5 billion in schools and local government facilities in the western states.[20]

According to a recent study, the construction of two new geothermal plants by Calpine Corporation in Siskiyou County, California will result in a total economic benefit of almost $114 million over 30 years.[21] This money will generate jobs, improve community living, and boost educational standards throughout the region.

Levelized Cost of Power

Most geothermal developers confirm that the cost for new projects ranges from 5.5 and 7.5 cents per kilowatt hour, with cost estimates under 5.5 cents per kilowatt hour relying on lower than average upfront financing agreements (see *Financing*), or considering only projects that are built as expansions of existing projects. The current price for geothermal expansion

[16] Capacity factors are projected for 2010. The average new geothermal power plant will come online at or near 2010 if development begins today. Also, 2010 is the earliest year capacity factor is rated in EIA's *Assumptions to the Annual Energy Outlook* 2006.

[17] Please see footnote number 6.

[18] National Geothermal Collaborative. *Geothermal Energy and Economic Development*. Retrieved March 13, 2006, from http://www.geocollaborative.org/publications/Geothermal_Energy_and_Economic_Development.pdf.

[19] Center for Energy Efficiency and Renewable Energy (CEERT). *Geothermal Power*. Accessed March 13, 2006, from http://www.ceert.org/ip/geothermal.html.

[20] Princeton Energy Research Inc (December 15, 1998). *Review of Federal Geothermal Royalties and Taxes*. Volume I, page 17. March 14, 2006, from http://waysandmeans.house.gov/hearings.asp?formmode=view&id=4069#_ftn4#_ftn4 (footnote 4)

[21] Gallo, David E. (June 2002). *The Economic Impact of Calpine's Geothermal Development Projects, Siskiyou County, California*. Prepared for Calpine Corporation. Center for Economic Development: California State University, Chico. Accessed March 23, 2006, from http://www.csuchico.edu/cedp/pdf/esp.calpine.pdf

projects can be competitive with coal-fired plants; greenfield projects can be competitive with natural gas projects.[22]

The chart shows that the cost of constructing a geothermal power plant is typically only half the capital cost. Developing and defining the geothermal resources represents almost as great a cost as building the power plant. O&M costs for geothermal are so low that they do not even appear in the chart below.

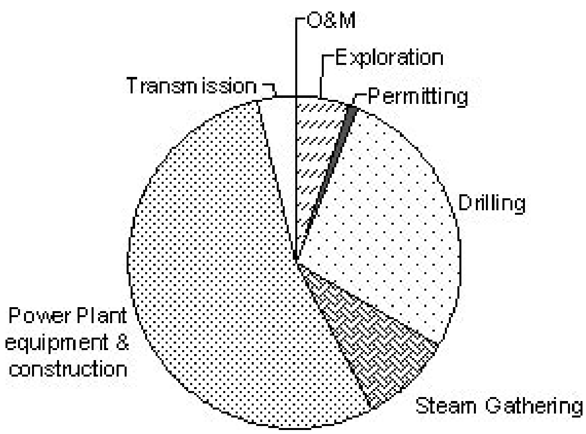

Figure 1. Typical Cost Breakdown of Geothermal Power Projects.

Power Cost Considerations

Availability and related characteristics impact the levelized cost of geothermal power. Several of these are compared in Table 2, below (for definitions, see footnotes).

Table 2. Power Technology Comparison.

Technology	Avg Hours available out of 24 hours/ day	Dispatch-able[23]	Available During Peaking Hours[24]	Expected Capacity Factor (percent)
Coal	24	Y	N	71
Nuclear	24	N	N	90
Geothermal	24	N	Y	86-95
Wind	8-9*	N	N	25-40
Solar	6-7	N	Y	24-33
Natural Cas Combustion Turbine	24	Y	Y	30-35
Hydropower	24	Y	Y	30-35
Biomass	24	Y	Y	83

*The wind figure refers to full operation only; this figure increases if partial wind generation is considered.

Each technology has its own set of issues not included in the table above. These include but are not limited to aesthetic concerns; environmental constraints; resource availability, cost, disposal, quality, and transportation; land degradation, extent of use, and zoning; water usage; and seasonal variability.

Nuclear plants, for example, use extensive land and water resources and have near and long-term spent fuel disposal concerns. Natural gas plants, in contrast to nuclear, suffer from considerable problems with fuel availability, a concern that has driven up the price of natural gas in recent years. Coal plants, while generally more economical than nuclear or natural gas facilities, use extensive land and water resources, suffer from significant environmental constraints such as air emissions and health impacts, and have mine tailings disposal problems. Solar and wind plants, with few water use issues, have land use, aesthetics, and resource availability problems. Geothermal is consistently available, but geothermal reservoirs must be managed properly in order to ensure sustainability, and thus geothermal plants have potential resource availability issues. Production from hydropower fluctuates with rainfall and seasonal variability. Biomass plants also suffered fuel availability problems.

Looking to the Future: Developing Geothermal Plants

Costs for geothermal generation at some facilities have decreased to half the original price per kilowatt hour of power in 1980,[25] when the first independent geothermal plants were installed, falling at a faster rate than coal. While geothermal's costs have steadily decreased throughout the years, those of natural gas have increased recently, often experiencing boom and bust type cycles that can negatively impact the economy. Most industry experts agree that geothermal is one of only a few alternative technologies that will compete economically with polluting technologies in the near term—even without considering the ancillary benefits of geothermal production.

Employment

Current Employment

Geothermal provides over 10 times more jobs per megawatt than natural gas, according to the EPA, as shown in Table 3 below.[26] And with a capacity factor three times greater than natural gas, geothermal produces even more electricity per megawatt constructed than natural gas.

In 2004 alone, the geothermal industry supplied about 4,583 direct power plant related jobs. The total direct, indirect, and induced impact of the industry in 2004 was 11,460 full-time

[22] CEC (March 2006). *Comparative Cost of California Central Station Electricity Generation Technologies*. Final Staff Report. Retrieved March 16, 2006, from http://www.energy.ca.gov/reports/2003-06-06_100-03-001F.PDF.

[23] A plant that is *Dispatchable* can increase or decrease generation, or be brought on line or shut down at the request of a utility's system operator.

[24] A plant that is capable of *Peaking* can be used to meet daily increases in electricity demand. Power demand tends to peak in late afternoon or early evening before gradually declining to its lowest point at night.

[25] Center for Energy Efficiency and Renewable Energy (CEERT). *Geothermal Power*. Accessed March 23, 2006, from http://www.ceert.org/ip/geothermal.html.

[26] US DOE (Jan 2006). *Employment Benefits of Using Geothermal Energy*, Geothermal Technologies Program. Retrieved March 17, 2006 from http://www1.eere.energy.gov/geothermal/employ_benefits.html.

Table 3. Natural Gas and Geothermal Employment Comparison.

Power Source	Construction Employment (jobs/MW)	O&M Employment (jobs/MW)	Total Employment for 500 MW Capacity (person-years)
Geothermal	4.0	1.7	27,050
Natural Gas	1.0	0.1	2,460

jobs. Employment is expected to increase in coming years as research and development expand.

Types of Jobs Created

Not only does geothermal provide more jobs than a tradition power plant, it also provides quality, long-term jobs. GEA's employment survey found that the overwhelming majority of geothermal jobs (95 percent) are permanent, and most are also full-time. At the power plants located in Lake County, California, almost 300 residents of the community are employed full-time. At The Geysers Geothermal Field in California, 425 full-time and 225 part-time residents of the community are employed.[27]

Geothermal provides long-term income for people with a diversity of job skills. People directly employed by the sector include welders; mechanics; pipe fitters; plumbers; machinists; electricians; carpenters; construction and drilling equipment operators and excavators; surveyors; architects and designers; geologists; hydrologists; electrical, mechanical, and structural engineers; HVAC technicians; food processing specialists; aquaculture and horticulture specialists; resort managers; spa developers; researchers; and government employees.[28]

Projected Employment

Looking to the future, geothermal employment should expand significantly. In 2005 alone, GEA has verified over 2000 megawatts of geothermal projects in the works. If only half of this development comes online within the next few years (a conservative estimate), these new facilities will support 6400 person-year (p-*y)[29] manufacturing and construction jobs and 740 power plant O&M jobs. If these 1000 MW last only 30 years – another conservative estimate – new production will create 28,600 p*-y jobs. This number increases if the additional jobs brought on by research, direct use applications, and other geothermal activities are considered. The number also excludes indirect employment impacts.

Take just one example of a developing project in Imperial County, California, at the Salton Sea Unit 6, where all permits have been secured for a 215 MW plant. Once this power plant produces electricity, it will be the largest renewable energy project of any kind in the United States. According to Congressional Testimony, the plant will employ 550 construction workers, eventually leading to more than 60 "high paid, fulltime positions." Testimony concludes that the plant will represent "the single largest capital investment in Imperial County, which is the most economically disadvantaged area in the state and one of the poorest in the county."[30]

Direct and Indirect Potential, Western States

According to a report by the Western Governors' Association (WGA),[31] development of the near-term geothermal potential of 5,600 MW of geothermal energy would result in

Table 4. Summary of Western States' Near-Term Geothermal Potential and Resulting Employment and Economic Contribution.

	New Power Capacity (Megawatts)	Direct, Indirect, and Induced Employment (Power Plant Jobs/ Construction & Manufacturing Employment)**	Economic Output ($2004)+
California	2,400	10,200 ft jobs/38,400 person*yrs	16.8 billion
Nevada	1,500	6,375 ft jobs/24,000 person*yrs	10.5 billion
Oregon	380	1,615 ft jobs/6,080 person*yrs	2.66 billion
Washington	50	212 ft jobs/800 person*yrs	350 million
Alaska	25	106 ft jobs/400 person*yrs	175 million
Arizona	20	85 ft jobs/320 person*yrs	140 million
Colorado	20	85 ft jobs/320 person*yrs	140 million
Hawaii	70	298 ft jobs/1,120 person*yrs	490 million
Idaho	860	3,655 ft jobs/13,760 person*yrs	6.02 billion
New Mexico	80	340 ft jobs/1,280 person*yrs	560 million
Utah	230	978 ft jobs/3,680 person*yrs	1.61 billion
Wyoming, Montana, Texas, Kansas, Nebraska, South Dakota, North Dakota	Potential Exists; Resource not studied in WGA Report	Not Studied	Not Studied
Total Western States (additional to current)	**5,635 MW**	**23,949 fulltime jobs/90,160 person*years of construction and manufacturing employment**	**$39,445,000,000. Almost 40 billion dollars to the U.S. economy**

** Power plant jobs are the direct, indirect and induced full-time jobs (ft jobs) created by reaching the full power production capacity indicated. Construction and manufacturing jobs are the direct, indirect and induced jobs necessary to build and supply the power plants at the full power capacity indicated. Construction and manufacturing jobs are expressed as full-time positions for one year (person*years), however these jobs will be spread out over several years depending upon the development time frame for new projects.

+Economic Output assumes an average cost of $280 million for a 100 MW plant; and assumes that for every dollar invested into a geothermal plant, the output to the economy is $2.50 (Hance 2005).

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[27] National Geothermal Collaborative. *Geothermal Energy and Economic Development*. Retrieved March 14, 2006, from http://www.geocollaborative.org/publications/Geothermal_Energy_and_Economic_Development.pdf.

[28] National Renewable Energy Laboratory (NREL) for U.S. Department of Energy (DOE). *Geothermal Development Job Types and Impacts.* Accessed March 14, 2006, from http://www.eere.energy.gov/geothermal/job_types.html.

[29] Person year corresponds to the employment of one person during one year.

[30] Statement of Vince Signorotti, *Testimony Before the Subcommittee on Select Revenue Measures of the House Committee on Ways and Means* (May 2005). Retrieved March 14, 2006, from http://waysandmeans.house.gov/hearings.asp?formmode=view&id=2698.

[31] Western Governors' Association (WGA). *CDEAC Geothermal Task Force*. Retrieved March 14, 2006, from http://www.westgov.org/wga/initiatives/cdeac/geothermal.htm.

the creation of almost 100,000 new power plant, manufacturing and construction jobs. Table 4 shows the employment and resulting economic output estimates based on WGA's near-term estimates:

Conclusion

Geothermal energy is an important contributor to the U.S. economy—not only through employment and taxes, but also through revenue stimulation across a variety of sectors, even outside the geothermal sector. The following summarizes some of the greatest socioeconomic benefits of geothermal generation and development.

Geothermal benefits the economy. For every dollar invested in geothermal energy, the resulting growth of output to the economy is $2.50. This means that the investment required for a 50 MW power plant would result in a growth of output of $350 million to the U.S. economy. If 1000 megawatts of new geothermal power comes online within the next three years as projected, the associated $2.8 billion investment will result in a total economic output of $7 billion nationwide.

Geothermal decreases electricity prices. In the long run, renewable energy resources can help decrease costs by providing low-cost, low-pollution options to meet U.S. energy needs. A recent study cites that increasing renewable energy generation, including geothermal, to 20 percent could "reduce natural gas use by 6 percent, while saving consumers nearly $27 billion."[32]

Geothermal meets state RPS requirements. When geothermal is used in conjunction with other renewables such as wind and solar to meet RPS requirements, geothermal can improve the overall stability of an electricity system by providing baseload power.

Geothermal reduces national security risks. Geothermal plants do not rely upon volatile international energy sources, nor are they terrorist targets. Also, geothermal facilities are local and smaller than large fossil or nuclear plants.

Geothermal incurs no hidden pollution costs. The cost of air emissions is rarely figured into the cost of fossil fuel power. Nor is the cost benefit of avoiding emissions at a geothermal facility. But a recent study attempted to do just that for geothermal—to monetize the cost savings from avoided emissions. Considering only carbon dioxide, sulfur oxides, nitrogen oxides, and particulate matter, cost savings from geothermal's avoided emissions totals $255.4 million per year.[33] Recent studies show that both air quality and renewable technologies would benefit from stricter emissions control.[34]

Geothermal incurs no hidden healthcare costs. According to one study, "health care is the single largest and fastest growing segment in numerous state and city budgets.[35]" A 2004 study found that health impacts associated with coal particulate matter emissions total almost $160 billion, and place a substantial burden on hospitals, health care professionals, health insurers, taxpayers, and company productivity, not to mention the individuals who suffer from these health impacts.[36]

Geothermal receives fewer subsidies than fossil fuel. According to the nonpartisan *Taxpayers for Common Sense*, removing fossil fuel subsidies could reduce U.S. carbon emissions by 65-70 million metric tons. The removal of fossil fuel subsidies has been advocated by the World Bank as the "first order of priority in instituting economic policies to protect local and global environments" that could also help spur new geothermal and renewable development. [37] Even though geothermal is a cleaner, more secure, and more stable alternative, taxpayers are charged millions of dollars to subsidize fossil fuel power plants instead of geothermal plants.

Geothermal: A Clean, Stable, Baseload Alternative

Geothermal does not provide the single answer to our electricity needs and pollution concerns, but it does provide one answer. The renewable energy source has already contributed billions of dollars to the U.S. economy; millions of dollars to small, rural communities; and thousands of secure, quality jobs to depressed areas. These remarkable economic impacts represent only a fraction of potential: the U.S. has developed just over 2 percent of the USGS' estimated geothermal capacity. If the resources from WGA's near term potential estimate are developed in the timeframe set forth by WGA, geothermal will contribute triple the current economic impact to the U.S. economy, while at the same time providing a supply of a stable, secure, environmentally friendly fuel.

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32 UCS (August 2005). *Renewable Energy Can Help Ease Natural Gas Crunch*. Retrieved March 14, 2006, from http://www.ucsusa.org/clean_energy/clean_energy_policies/renewable-energy-can-help-ease-natural-gas-crunch.html.

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