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THE UNITED STATES OF AMERICA COUNTRY UPDATE 2010

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ABSTRACT

Geothermal energy is used for electric power generation and direct utilization in the United States. The present installed capacity (gross) for electric power generation is 3168 MWe[1] (installed) with 1,748 MWe net (running) delivering power to the gird producing approximately 14,974 GWh per year for a 0.54 gross capacity factor and a 0.98 net capacity factor. Geothermal electric power plants are located in California, Nevada, Utah and Hawaii with recent installation in Alaska, Idaho, New Mexico, Oregon, and Wyoming, with 500 MWe being added the last five years. The two largest concentrations of plants are at The Geysers in northern California and the Imperial Valley in southern California. The Geysers continues to receive waste water from Clear Lake and Santa Rosa, California that is injected into the field and has resulted in the recovery of approximately 200 MWe of power generation. The lowest temperature installed plant is at Chena Hot Springs in Alaska, where binary cycle plants uses 74°C geothermal fluids to run three units for a total of 730 kW (gross). With the recent passing of the production tax credit by the federal government (2.0 cents/kWh) and renewable portfolio standards requiring investments in renewable energy, the annual growth rate for electric power generation over the past five years is 3.7 percent. The direct utilization of geothermal energy includes the heating of pools and spas, greenhouses and aquaculture facilities, space heating and district heating, snow melting, agricultural drying, industrial applications and ground-source heat pumps. The installed capacity is 12,611 MWt and the annual energy use is 56,552 TJ or 15,709 GWh. The largest application is ground-source (geothermal) heat pumps (84% of the energy use), and the next largest direct-use is fish farming and swimming pool heating. Direct utilization (without heat pumps) remainded static over the past five years with gains balancing losses; however, ground-source heat pumps are being installed at a 13% annual growth rate with one million units (12 kW size) in operation. The energy saving from all geothermal energy use is about 6.9 million tonnes of equivalent fuel oil per year (45.7 million barrels) and reduces air pollution by almost 6.0 million tonnes of carbon and 17.0 million tonnes of CO_2 annually (compared to fuel oil).

[1] The total installed capacity number (3168 MWe) closely parallels estimates of recent reports such as the Geothermal Energy Associations *U.S. Geothermal Power Production and Development Update* which estimates installed capacity to be 3153 MWe (See Figure 2, page 4)

INTRODUCTION

Geothermal resources capable of supporting electrical generation and/or direct use projects are found primarily in the Western United States, where most of the recent volcanic and mountain building activity have occurred (Figure 1). The San Andreas fault, running through California from the Imperial Valley to the San Francisco area, and the subduction zone off coast of northern California, Oregon and Washington and Cascade volcanism are the source of much of the geothermal activity in the United States. However, geothermal (ground-source) heat pumps extend the utilization to all 50 states. The total identified potential for electrical production is estimated at 21,000 MWe (above 150°C) and 42 EJ (between 90° and 150°C) of beneficial heat (Muffler, 1979), and a recent estimate by the U.S. Geological Survey estimates a mean probability of electrical power generation from identified geothermal resources in12 western states during the next 30 years of 8,866 MWe (USGS, 2008), which would nearly triple the existing electrical capacity.

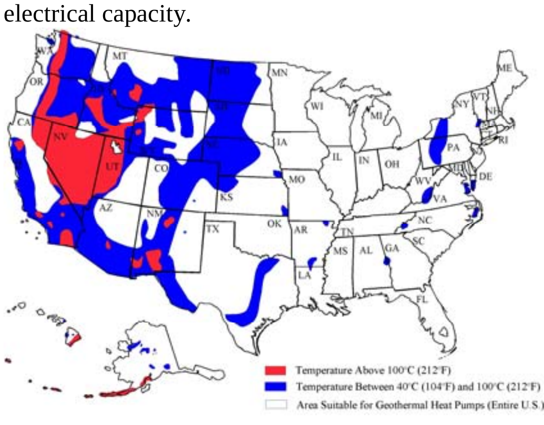

Figure 1: Geothermal resource map of the United States.

Achieving this electric capacity potential will be dependent upon a number of factors including competing prices for energy and incentive programs that encourage development of renewable energy resources. Recently passed Renewable Portfolio Standards (RPS) in a number of states along with the extension of the Production Tax Credit (PTC) by Congress to 2015, which provides a 2.0 cent per kilowatt hour credit, have attracted developers to start new projects. Other incentives are the recent stimulus funds for geothermal energy, at US$400 million, approved by Congress will shortly be allocated for various types of geothermal projects, along with a tax credit (30% of the cost up to US$1,500) for geothermal heat pump installations under the 2005 Energy Policy Act and extended by the American Recovery and Reinvestment Act of 2009. All of these measures will greatly improve geothermal's ability to compete with fossil fuel generation, both for electrical energy and direct-use. The federal government has also approved a 30% investment tax credit as a grant for commercial operation of power plants. A recent report by the Energy Information Administration (EIA, 2009), confirms the continued growth of renewables as fossil fuel use plummet and nuclear power stalls.

The United States continues to lead the world in installed geothermal power capacity as well as in electrical generations, and along with geothermal heat pumps, is one of the leaders in direct-use applications.

Geothermal energy remains, however, a small contributor to the electric power capacity and generation in the United States. In 2009, geothermal plants constituted about 0.27 percent of the total operable power capacity, and those plants contributed an estimated 0.48 percent of the total generation.

Since the last U.S. Country Update was completed in 2005 gross geothermal electrical production capacity has increased in the United States by approximately 500 MWe to a total an installed capacity of 3167.66 MWe and a net running capacity of 1747.56 MWe due to derating of plants in The Geysers, for a gross capacity factor of 0.54 and a net of 0.98. The low gross value is due to plants, especially in The Geysers, operating in a load following mode rather than in a base load mode and due to a reduction in pressure and output of the steam field. Total generation in 2007 was 14,974 GWh and the geothermal electric power generation accounted for 4% of the total renewable based electricity consumption in the United States. On a state level, geothermal electric generation is a major player in California and Nevada. It is a minor source of power in the other states. The generation in California provides about 4.5% of the state's energy consumption. It is also significant on the Big Island of Hawaii where it now provides approximately 20% of the electricity requirements. Recent projects have brought several new states into the electricity "club", including, Alaska, Idaho, New Mexico, Oregon and Wyoming. Alaska is most noted, as a 250 kW binary cycle generator installed in 2006 uses the lowest temperature geothermal fluid in the world to produce electricity at 74°C, however, it should be noted that it also has 4°C cooling water from a stream allowing for an acceptable "ΔT" (Lund, 2006). The growth in installed capacity during the 1980s was about 11 percent, however, from 1990-1998 it averaged on 0.14 percent due to a leveling off of new plant construction, and from 2000 to 2004 only approximately 70 MWe of new capacity was added. Since, 2005, the growth has been almost 20 percent.

The period 1990-2004 also saw a reduction at The Geysers geothermal field in northern California from 1,875 to around 1,529 MWe installed capacity and 945 MWe running capacity. Today, the installed capacity is 1584 MWe and 844 MWe running capacity. This was due to the closing of four units and a reduction in the steam availability. Some capacity has been restored due to the construction of two effluent pipelines, one from Clear Lake and the other from Santa Rosa, that brings about 72,000 tonnes of water per day (19 million gallons/day) to The Geysers for injection. This has restored an estimated 200 MWe of capacity to the field.

Direct-use, other than geothermal heat pumps, has remained static with increases being balanced by closing of some facilities. The main increases has been in expanding the Boise City District Heating System from 48 to 58 buildings; adding additional wells for space heating in Klamath Falls; expanding the snow melting system on the Oregon Institute of Technology campus from 316 m^2 to 3,753 m^2, increasing the amount of aquaculture product being produced, mainly Tilapia; starting two biodiesel plants; adding an absorption chiller for keeping the Ice Museum at Chena Hot Springs in Alaska intact during the summer months, and adding additional space heating to the Peppermill Casino in Reno. Losses have been the closing of the district heating systems at the California Correctional Center (now using natural gas) and the New Mexico University heating system (due to difficulty with maintenance), and the closing of the Empire onion dehydration plant (due to competition with imported garlic from China) near Gerlach, Nevada.

Geothermal heat pumps have seen the largest growth, increasing from and estimated 600,000 to 1,000,000 equivalent 12 kW installed units. The estimated installation rate is from 100,000 to 120,000 units per year, or about a 12 to 13 percent annual growth, with most of the growth taking place in the mid-western and eastern states. A few states have tax rebate programs for geothermal heat pumps, and as mentioned above, Congress has established a tax credit of 30% of costs up to $1,500 for installations. Otherwise, there is little support for implementing direct-use projects.

Enhanced (Engineered) Geothermal Systems (EGS) is the current R&D interest of the U.S. Department of Energy, Office of Geothermal Technologies as part of a revived national geothermal program. EGS includes the earlier hot dry rock technology, but now includes any other method in which to improve geothermal reservoir performance. EGS is associated with both magmatic and high heat producing crustal sources of geothermal energy commonly at depths of about 4 to 5 km to reach 200°C, but also having applications with normal gradient resources. However, EGC projects are currently at an early experimental demonstration stage. Several technological challenges need to be met for widespread efficient use of EGS. The key technical and economic changes for EGS over the next two decades will be to achieve economic stimulation of multiple reservoirs with sufficient volumes to sustain long term production, with low flow impedance, limited short-circuiting fractures and manageable water loss (Tester et al., 2006). Over the next 10 to 30 years, lessons learned while deploying early EGS power plants can reasonably be expected to facilitate wider, efficient deployment of EGS technologies for both power production and direct use, or as in Europe in a combined heat and power installation. One of the public relations problems associated with EGS projects, is the generation of micro earthquakes (usually <3.5 on the Richter scale), that has slowed, threatened or shut down projects.

In a Massachusetts Institute of Technology (MIT)-led assessment (Tester et al., 2006), the U.S. geothermal resource was estimated to be 14 million EJ with a technically extractable capacity of about 1,200 GWe to depths of 10 km. The report estimated that with reasonable investment in R&D, EGS could provide 100 GWe or more of cost-competitive generating capacity in the next 50 years. It further stated: "*…EGS provides a secure source of power for the long term that would help protect American against economic instabilities resulting from fuel price fluctuations or supply disruptions.*" Unfortunately, a current project near The Geysers has been placed on hold due to the inferred generation of micro earthquakes affecting nearby residences.

PRODUCTION OF ELECTRICITY

Table 1 presents operable electric production capacity and power generation in the United States from all sources for 2005-2008. All data in this table came from the USDOE Energy Information Administration (EIA, 2009)

Geothermal power production is summarized in Table 2 by plant and location. The total installed capacity in 2009 was 3,168 MWe producing 14,974 GWh from a running capacity of 1,748 MWe. A total of 500 MWe has been installed since the WGC2005 report, amounting to a 20 percent increase or 3.7 percent annual increase.

Installed and Future Capacity Update

Alaska

Alaska's first geothermal power plant came online in 2006 in Chena Hot Springs. It is a small organic rankine cycle (ORC) unit (250 kW gross) and produces electricity from the area's low temperature (74^{o}C) geothermal resource. Since coming online the power plant has added another 250 kW unit as well as a 280 kW unit, bringing total production capacity to 730 kW (gross).

Alaska currently has 70 to 115 MW of planned geothermal production coming down the pipeline. Of projects with potential to come online, the Southwest Alaska Regional Geothermal Energy Project, 25 MW, is in an exploratory drilling and resource confirmation phase. Other notable projects are Tongass (20 MW), Unalaska (10–50 MW), Pilgrim Hot Springs (10 MW), and Chena Hot Springs II (5-10 MW).

Arizona

Geothermal power production does not currently occur in Arizona. However, the Arizona Public Service is currently planning a 2 – 20 MW development known as the Clifton geothermal project. Also, although the scope of electricity production is not known, Northern Arizona University is planning a geothermal plant for which they have federal funding for drilling.

California

Current geothermal electricity production capacity in California is approximately 2621 MW. In 2007, 4.5% of California's electricity generation came from geothermal power plants, amounting to a net total of 12,558 GWh. The 50 MW North Brawley facility is the states most recent geothermal power plant addition. Generally, geothermal power generation remains concentrated in California with the majority of production occurring at The Geysers in the north and Imperial Valley in the south.

California has approximately 1841.8 – 2435.8 MW of planned geothermal resource production in various stages of development. Production drilling and facility construction are underway at Western GeoPower Corp.'s Unit 1 (35 MW) at the Geysers as well as CHAR, LLC's Hudson Ranch I (49.9 MW). Final permitting and PPA's are being secured for Ormat Technologies East Brawley project (30 MW), Calpine Corporations Buckeye-North Geysers (30 MW) and Wildhorse-North Geysers (30 MW) projects, and CalEnergy's Black Rock 1, 2, and 3 units (53 MW each) (California Energy Commission, 2009).

Colorado

Although there are no geothermal power plants currently producing electricity in Colorado, Mount Princeton Geothermal is currently conducting exploratory drilling and resource confirmation operations at its Mount Princeton Hot Springs project site. Total capacity of the project is expected to be 10 MW once completed.

Florida

No geothermal power production is occurring in Florida at this time. However, Quantum Resources Management, and Pratt and Whitney (UTC Power) are in the early stages of developing a 200 kW co-production geothermal power project. The project has the potential to produce 1 MW of power.

Hawaii

There is only one geothermal power plant in all of Hawaii. Located on the big island, the Puna Geothermal Venture facility has a 35 MW nameplate capacity and delivers 25–35 MW of energy on a continuous basis and supplies 20% of the electricity needs of the big island. Ormat is in the process of securing a PPA and final permitting for an 8 MW expansion of its Puna project.

Idaho

Idaho's first geothermal power plant, Raft River, came online in January 2008. Raft River is a binary plant that uses a 150°C resource and has a nameplate production capacity of 15.8 MW. Current net production output is between 10.5 and 11.5 MW. US Geothermal is securing a PPA and final permitting for a 13 – 26 MW expansion of the Raft River plant.

Another geothermal company, Idatherm, is developing a number of projects throughout Idaho. Idatherm has begun exploratory drilling and resource confirmation operations for its Willow Springs project (100 MW). It is also planning to develop its China Cap (100 MW), Preston Area Project (50 MW), and Sulfur Springs (25 – 50 MW) resources but is still in the process of conducting initial exploratory drilling and securing rights to resource. Total potential geothermal production for Idaho is 238 to 326 MW (Idaho Office of Energy Resources, 2009).

Nevada

In 2008 Nevada had 18 geothermal power plants with a total nameplate capacity of 333 MW and with a total gross output of 10,791 MWh. In 2009 Nevada increased its installed geothermal capacity with the addition of the Stillwater (ENEL, 47.3 MW), Salt Wells (ENEL, 18.6 MW), and the Blue Mountain "Faulkner 1" (Nevada Geothermal Power, 49.5 MW) power plants. Currently Nevada has more developing projects than any other state and it is expected that gross capacity will increase significantly in the future. The following companies have begun production drilling and facility construction at various project sites: Vulcan Power (Salt Wells, 175 – 245 MW), Presco Energy (Rye Patch, 13 MW), and US Geothermal (San Emidio "Repower" Project, 8.4 MW), Ormat (Jersey Valley, 18 – 30 MW). Many other companies are in the process of securing PPA's and final permitting for a number of projects and other companies are in the early exploratory stages of developing numerous geothermal resources. Nevada currently has 1876 to 3473 MW of geothermal capacity in development. (Nevada Bureau of Mines and Geology, 2009).

New Mexico

In July 2008, a 0.24 MW pilot installation project came online at Burgetts Greenhouses near Animas. The pilot installation is part of a larger project known as Lightning Dock that aims to bring a 20 MW capacity geothermal power plant online in 2009.

Oregon

While there is only one small unit producing geothermal electricity, significant developments are forthcoming. The Oregon Institute of Technology (OIT) has installed a 280 kW (gross) binary units and is currently producing power for use on campus – the first campus in the world to generate its own power from a resource directly under campus. OIT has also completed production drilling of a 1,600-m deep well and will install a 1.0 MW binary power unit by 2011 using the 93ºC resource at 126 L/s. Davenport Power, U.S. Renewables Group, and Riverstone are securing a PPA and final permitting for their 120 MW Newberry Geothermal project as is Nevada Geothermal Power for its 40 – 60 MW Crump Geyser project. U.S. Geothermal, Inc. successfully completed the drilling of its second full sized production well at Neil Hot Springs (20 – 26 MW) in October 2009. Overall there are 317.2 to 368.2 of potential geothermal power capacity in planning in Oregon.

Utah

Currently, Utah has three power plants online. Unit 1 of the Blundell Plant has a gross capacity of 25 MW and Unit 2 has a capacity of 11 MW. Utah's third power plant came online in December 2008 and was the first commercial power plant in the state in more than 20 years. The Thermo Hot Springs power plant, a Raser Techologies operation, came online in 2009 and has a gross capacity of 14 MW and is expected to generate with a net capacity of approximately 10 MW. Shoshone Renaissance Geothermal Project. ENEL North America has begun exploratory drilling and resource confirmation operations at its Cove Fort (69 MW) project site. Other companies have potential geothermal sites that are in the early stages of planning/development and overall Utah has 272.4 to 332.4 MW of planned geothermal capacity for future production.

Washington

Although Washington is not currently producing power from any of its geothermal resources Vulcan Power is planning to develop the Mt. Baker geothermal resource. AltaRock Energy is pursuing an EGS project in Snohomish County.

Wyoming

In August 2008, a 250 kW Ormat organic Rankine cycle (ORC) power unit was installed at Rocky Mountain Oil Test Site and a month later it began operating. As of January 2009, the unit had produced more than 485 MWh of power from 413,000 tonnes of hot water annually. The demonstration project will operate until September 2009. During its operation there will be an evaluation of how to reduce fluctuations of power and to generate more than 250 kW.

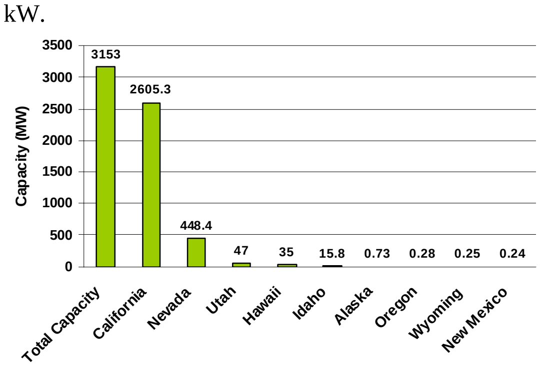

Figure 2. November 2009 Geothermal Power Capacity Online (MW). Source: GEA

Table A. Developing projects by state.

State	Phase I to Phase IV	TOTAL (with unconfirmed)
Alaska	5/50 – 95 MW	6/70 – 115 MW
Arizona	1/2 – 20 MW	1/2 – 20 MW
California	32/1554.9 – 1938.9 MW	37/1841.8 – 2435.8 MW
Colorado	1/10 MW	1/10 MW
Florida	1/0.2 – 1 MW	1/0.2 – 1 MW
Hawaii	2/8 MW	2/8 MW
Idaho	5/238 – 326 MW	5/238 – 326 MW
Louisiana	0	1/.05 MW
Mississippi	0	1/.05 MW
Nevada	60/1776.4 – 3323.4 MW	64/1876.4 – 3473.4 MW
New Mexico	1/20 MW	1/20 MW
Oregon	13/317.2 – 368.2 MW	13/317.2 – 368.2 MW
Utah	10/272.4 – 332.4 MW	10/272.4 – 332.4 MW
Washington	1/Unspecified	1/Unspecified
Total	132 Projects 4249.1 – 6442.9 MW	144 Projects 4699.9 – 7109.9 MW

Phase I: Indentify site, secured rights to resource, initial, exploration drilling. Phase II: Exploratory drilling and confirmation underway; PPA not secured. Phase III: Securing PPA and final permits. Phase IV: Production drilling underway; facility under construction. Unconfirmed: Proposed projects that may or may not have secured the rights to the resource, but some exploration has been done on the site. *Source: GEA.*

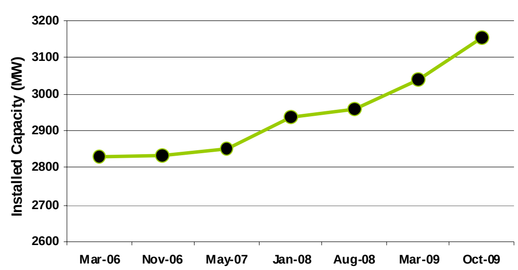

Figure 3. Total Installed Capacity 2006 – 2009. Source: GEA

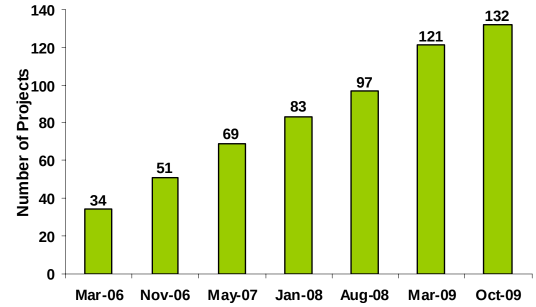

Figure 4. Total confirmed development project for electricity power 2006-2009. Source: GEA

GEOTHERMAL DIRECT UTILIZATION

Background

Geothermal energy is estimated to currently supply for direct heat uses and geothermal (ground-source) heat pumps 56,552 TJ/yr (15,709 GWh/yr) of heat energy in the United States. The corresponding installed capacity is 12,611 MWt. Of these values, direct-use is 9152 TJ/yr (2,542 GWh/yr) and 611 MWt, and geothermal heat pumps the remainder. It should be noted that values for the capacity and energy supplied by geothermal heat pumps are only approximate (and probably conservative) since it is difficult to determine the exact number of units installed, and since most are sized for the cooling load, they are generally oversized in terms of capacity for the heating load.

Most of the direct use applications have remained constant or decreased slights over the past five years; however geothermal heat pumps have increased significantly. A total of 20 new projects have come on line in the past five years. Agricultural drying has decreased the most due to the closing of the onion/garlic dehydration plant at Empire, Nevada. Two district heating projects have also shut down; the Litchfield Correctional Facility in California and the New Mexico State University system. There have been slight increase in snow melting, cooling and fish farming, with a major increase in industrial process heating due to two biodiesel plants (Oregon and Nevada), a brewery (Oregon) and a laundry (California) coming on line. In summary, when considering direct-use without geothermal heat pumps, the distribution of annual energy use is as follows: 34% for fish farming, 28% for bathing and swimming pool heating, 15% for individual space heating, 9% for greenhouse heating, 8% for district heating, 3% for agricultural drying, 2% for industrial process heating, 1% for cooling and <1% for snow melting. Geothermal heat pumps accounts for 81% of the annual use, and has almost double (1.81 times) in the past five years with a 13% annual growth rate.

Figure 5 shows the direct-use development over the past 35 years, without heat pumps. A summary of direct-heat use by category is presented in Table 5.

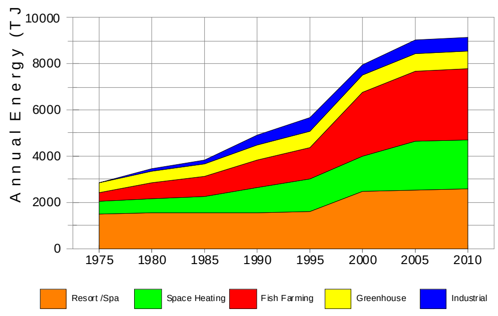

Figure 5. Direct-use growth in the United States.

Space Heating

Space heating of individual buildings (estimated at over 2,000 in 17 states) is mainly concentrated in Klamath Falls, Oregon where about 600 shallow wells have been drilled to heat homes, apartment houses and businesses. Most of these wells use downhole heat exchangers to supply heat to the buildings, thus, conserving the geothermal water (Culver and Lund, 1999). A similar use of downhole heat exchangers is found in the Moana area of Reno, Nevada (Flynn, 2001). Installed capacity is 140 MWt and annual energy use is 1361 TJ.

District Heating

There are 20 geothermal district-heating systems in the United States, most being limited to a few buildings. The newest is a small project in northern California (Merrick, 2002 and 2004). In this rural community of Canby, geothermal heat is used for heating buildings, a greenhouse, and most recently driers and washers in a laundry (Merrick, 2009). The city system in Boise, Idaho has added 10 buildings to their system and will be extended to Boise State University next year. Klamath Falls system has expanded by adding a brewery and an additional greenhouse. Extensions have also been added for a future commercial develop on the edge of a local lake in town. The local hospital and Oregon Institute of Technology have both added new buildings to their systems (Lund and Boyd, 2009). Installed capacity is 75 MWt and annual energy use is 773 TJ.

Aquaculture Pond and Raceway Heating

There are 51 aquaculture sites in 11 states using geothermal energy. The largest concentration of this use is in the Imperial Valley in southern California and operations along the Snake River Plain in southern Idaho. There is a report that some of the facilities in the Imperial Valley have closed, but reliable information is lacking. A large facility at Kelly Hot Springs in northern California has been expanding and now produces slightly over half a million kg of tilapia annually. Two unique aquaculture related projects are in operation in Idaho and Colorado – that of raising alligators (Clutter, 2002). Recent trends in the U.S. aquaculture industry have seen a decline in growth due to saturation of the market and competition from imports. Installed capacity is 142 MWt and annual energy use is 3074 TJ.

Greenhouse Heating

There are 44 greenhouse operations in nine states using geothermal energy. These cover an area of about 45 ha, have an installed heat capacity of 97 MWt and an annual energy use of 773 TJ/yr (215 GWh). The main products raised are potted plants and cut flowers for local markets. Some tree seedlings and vegetables are also grown in Oregon; however vegetable raising is normally not economically competitive with imports from Central America, unless they are organically grown. One unusual greenhouse product, started recently, is spider mites grown on lima bean plants at Liskey Farms south of Klamath Falls, Oregon. They are grown for their eggs which are then shipped south as feed for predator mites, which in turn are sold to farms to eat spider mites – a complicated process, as the mites and eggs are almost microscopic in size and difficult to see (Northwest Farm Credit Services, 2009).

Industrial Applications and Agricultural Drying

Industrial applications have increased significantly due to the addition of two biodiesel plants (Oregon and Nevada). These plants primarily use geothermal energy for the distillation of waste grease from restaurants, but one also used canola oil. Small industrial uses include clothes driers and washer installed in Canby, California, and a brewery using heat from the Klamath Falls district heating system for brewing beer and heating the building (Chiasson 2006, Merrick, 2009). The main loss is the closing of an onion/garlic dehydration plant at Empire, Nevada due to competition with imported garlic from China. The installed industrial capacity for these two applications is 40 MWt and the annual energy use 519 TJ/yr (144 GWh/yr) with nine facilities located in three states.

Cooling and Snow Melting

The two major uses of geothermal energy are for pavement snow melting, on the Oregon Institute of Technology (OIT) campus, and keeping the Aurora Ice Museum frozen year-round at Chena Hot Springs, Alaska. OIT has increase their campus snow melt system from 3165 m2 to 3,7530 m2 and the ammonia absorption chiller in Alaska keeps a 1,000 tonnes of ice frozen even though it reaches 32^{o}C outside in the summer. Over 10,000 visitors a year visit the facility that has a bar, beds and many ice sculptures (Holdman and Erickson, 2006). The installed capacity for this application is 2.3 MWt and the annual energy use is 48 TJ/yr (13 GWh/yr).

Spas and Swimming Pools

This is one of the more difficult applications to quantify and even to find all the actual sites, as most owners do not know their average and peak flow rates, as well as the inlet and outlet temperatures. Most of the locations and some of the data, have come from a number of hot spring/spa publications available for most states. As a result, we often have to estimate the capacity and energy use based on our experience with similar facilities. There are 242 facilities in 17 states that we have identified, with an estimated installed capacity of 113 MWt and annual energy use of 2557 TJ/yr (711 GWh/yr).

Geothermal (Ground-Source) Heat Pumps

The number of installed geothermal heat pumps has steadily increased over the past 15 years with an estimated 100,000 to 120,000 equivalent 12 kWt units installed this past year. Present estimates are that there are at least one million units installed, mainly in the mid-western and eastern states. The present estimates are that approximately 70% of the units are installed in residences and the remaining 30% in commercial and institutional buildings. Approximately 90% of the units are closed loop (ground-coupled) and the remaining open loop (water-source). Within the residential sector, of the closed loops systems, approximately 30% are vertical and 70% horizontal, as the latter are cheaper to install. In the institutional and commercial sector, 90% are vertical and only 10% horizontal, contrained by ground space in urban area. Presently, the ratio of new installation to retrofit installations is 3:1. The estimated full load hours in heating mode is 2000/yr, and in cooling mode is 1000/yr. The installation cost is estimated at US$6,000 per ton (3.5 kW) for residential and US$7,000 per ton (3.5 kW) for commercial. The units are found in all 50 states and are growing 12 to 13% a year. It is presently a US$2 to US$3 billion annual industry. Even though the actual number of installed units is difficult to determine, input has been provided from various industry representatives for these estimates (personal communication: John Geyer, Warren (Trey) Austin, and Patrick Hughes, October, 2009, Dan Ellis, November 2009). The current installed capacity is 12,000 MWt and the annual energy use in the heating mode is 40,100 TJ/yr (11,147 GWh/yr). The largest installation currently under construction is for Ball State University, Indiana where 4,100 vertical loops are being installed to heat and cool over 40 buildings.

Conclusions – Direct-Use

The distribution of capacity and annual energy use for the various direct-use applications are shown in Table 5 and are based on records keep at the Geo-Heat Center. We estimate that the estimates are anywhere from 10 to 20% under reported, due to their small sizes, lack of data and often isolated locations.

The growth of direct use over the past five years is all due to the increased use of geothermal heat pumps, as traditional direct-use development has remained flat as shown in Figure 4. Unfortunately, there is little interest for direct-use at the federal level, as their interests are mainly in promoting and developing Enhanced (Engineered) Geothermal Systems (EGS). There are few incentives for the traditional direct-use development, but as mentioned earlier, there are tax incentives for geothermal heat pumps at the federal level and in some states such as Oregon. Since, most direct-use projects are small, there are few, if any, developers and/or investors who are interested in supporting these uses.

WELLS DRILLED

Most wells drilled for geothermal use were for power generation. Assuming 3 MWe per well, and each approximately 2,000 meters deep (deeper at The Geysers and shallower in Nevada where most of the wells were drilled), the increase of 500 MWe added approximately 400 km (vertical) including exploratory and injection wells, and direct use added approximately 4 km. Most direct-use work concentrated on improving and refurbishing existing wells. See Table 6 for details. Geothermal heat pumps wells, which are not included in this table, probably added 200,000 vertical holes at 75 m each for a total of 15,000 km over the five years.

PROFESSIONAL GEOTHERMAL PERSONNEL

Professional geothermal personnel with university degrees are higher mainly due to an increase in the installed capacity of power plants. Geothermal Power plants are estimated to employ 1.7 person/years per installed megawatt (Kagel, 2006). It is assumed that approximately 0.5 person/year is due to professional personnel. Due to limits on funding from USDOE Office of Geothermal Technologies, during the years 2005 to 2008, personnel in private industry as well as with the government institutions, as well as National Laboratories and Universities were reduced. Only about 50 person/years are due to direct-use geothermal. See Table 7 for details.

INVESTMENT IN GEOTHERMAL

Again, the majority of the investment in geothermal was for geothermal electric power plants. We estimate that US$4,000 (Western Governor's Association, 2006)is invested for every kilowatt of installed capacity. Thus, for the new 500 MWe of installed capacity over the past five years, US$2.000 billion was invested. Above half of this was for field and plant development and 25% each for R&D and for the operation. Direct-use only added about US$2,000 million; however, not shown in Table 8 is the approximately US$2.5 billion is spent annually on geothermal heat pump installations and equipment (personal communication, John Geyer, Oct. 2009).

ENERGY AND CARBON SAVINGS

The total electricity produced from geothermal energy in the U.S. is equivalent to savings 25.5 million barrels (3.82 million tonnes) of fuel oil per years (generating at 0.35 efficiency). This produces a savings of 3.35 million tonnes of carbon annually. The total direct utilization including geothermal heat pump energy use in the U.S. is equivalent to saving 13.3 million barrels (2.01 tonnes) of fuel oil per years (producing heat at 0.70 efficiency). This produces a savings of 1.76 million tonnes of carbon annually. If the savings in the cooling mode of geothermal heat pumps is considered, then this is equivalent to an additional savings of 6.9 million barrels (1.03 million tonnes) of oil annually.

In total, the savings from present geothermal energy production in the U.S., both electricity and direct-use amounts to 45.7 million barrels (6.86 million tonnes) of fuel oil equivalent (TOE) per year, and reduces air pollution by 6.00 million tonnes of carbon annually. CO_2 reduction is estimated at 17.0 million tonnes

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TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr *	Capac-ity Mwe **	Gross Prod. GWh/yr
In operation in December 2009	3,165.0	15.0	850,486.0	2,928.0	97,999.0	248.1	105,764.0	806.2	33,542.0	127.7	1,087,791.0	4,110.3
Under construction in December 2009	0											
Funds committed, but not yet under construction in December 2009	4249-6443 132 projects											
Total projected use by 2015	7482-9676											

Ref: www.eia.doe.gov
* 97 percent Hydro
** 994,888 net summer capacity, 1,031,978 net winter capacity

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2009

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2009[3)] GWh/yr	Total under Constr. or Planned MWe
ALASKA						0.73	0.50	3.94	50-95
ARIZONA						0.00			2-20
CALIFORNIA						2,620.80	1,471.75	12,558.15	1,555-1,939
COLORADO						0.00			10
FLORIDA						0.00			0.2-1
HAWAII						35.00	30.00	236.52	8
IDAHO						15.80	11.50	90.67	238-326
NEVADA						447.56	200.36	1,755.21	1,776-3,323
NEW MEXICO						0.24	0.15	0.54	20
OREGON						0.28	0.15	0.11	317-368
UTAH						47.00	33.00	328.42	272-332
WYOMING						0.25	0.15	0.48	0
Total						3,167.66	1,747.56	14,974.04	4,249-6,443

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2009 (other than heat pumps)

1) I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
H = Individual space heating (other than heat pumps)
D = District heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)

2) Enthalpy information is given only if there is steam or two-phase flow

3) Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.004184 (MW = 10^6 W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

4) Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

5) Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

Note: please report all numbers to three significant figures.

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization		
		Flow Rate	Temperature (^{o}C)		Enthalpy[2] (kJ/kg)			Ave. Flow	Energy[4]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5]
Alaska	H,G,B,C						7.8		156.2	0.6
Arkansas	H						0.4		7.3	0.7
Arizona	H,F,B						23.5		317.4	0.43
California	D,H,G,F,B						105.1		2183.6	0.7
Colorado	D,H,G,F,B						29.5		627.6	0.7
Georgia	H,B						0.6		11.0	0.6
Idaho	D,H,G,F,B						89.3		1429.1	0.5
Montana	H,G,F,B						15.8		297.8	0.6
New Mexico	D,H,G,F,B						38.7		335.7	0.3
Nevada	D,H,F,A,B						74.8		1153.6	0.5
New York	H,B						0.9		12.1	0.4
Oregon	D,H,G,F,I,A,S,B						78.2		812.4	0.3
South Dakota	D,H,F,B						66.3		577.6	0.28
Texas	H,B						4.0		27.4	0.2
Utah	H,G,F,B						45.8		449.9	0.3
Virginia	H						0.3		3.1	0.3
Washington	B						1.9		45.5	0.8
West Virginia	B						0.1		3.7	0.8
Wyoming	H,G,F,S,B						28.3		701.0	0.8
TOTAL							611.5		9151.8	0.47

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2009

This table should report thermal energy used (i.e. energy removed from the ground or water) and report separately heat rejected to the ground or water in the cooling mode. Cooling energy numbers will be used to calculate carbon offsets.

1) Report the average ground temperature for ground-coupled units or average well water or lake water temperature for water-source heat pumps

2) Report type of installation as follows: V = vertical ground coupled (TJ = 10^{12} J)
H = horizontal ground coupled
W = water source (well or lake water)
O = others (please describe)

3) Report the COP = (output thermal energy/input energy of compressor) for your climate

4) Report the equivalent full load operating hours per year, or = capacity factor x 8760

5) Thermal energy (TJ/yr) = flow rate in loop (kg/s) x [(inlet temp. (°C) - outlet temp. (°C)] x 0.1319
or = rated output energy (kJ/hr) x [(COP - 1)/COP] x equivalent full load hours/yr

Note: please report all numbers to three significant figures

Locality	Ground or water temp. (°C)[1)]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2)] *	COP[3)]	Heating Equivalent Full Load Hr/Year[4)]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
<u>States</u>								
Northeast: 20%	5-25	12.0		V=45%	3.5			
Midwest: 34%	5-25	12.0		H=45%	3.5			
South: 35%	5-25	12.0		W=10%	3.5			
West: 11%	5-25	12.0			3.5			
			1,000,000			2,000	47,400	29,600
TOTAL			1,000,000				47,400	29,600

Ref: www.eia.doe.gov

* Residential: V/H = 30%/70%, Commercial/Institutional: V/H = 90%/10%

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2009

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less,
since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]	139.89	1360.6	0.31
District Heating [4]	75.10	773.2	0.33
Air Conditioning (Cooling)	2.31	47.6	0.50
Greenhouse Heating	96.91	799.8	0.26
Fish Farming	141.95	3074.0	0.69
Animal Farming	0.00	0.0	0.00
Agricultural Drying[5]	22.41	292.0	0.41
Industrial Process Heat[6]	17.43	227.1	0.41
Snow Melting	2.53	20.0	0.25
Bathing and Swimming[7]	112.93	2557.5	0.72
Other Uses (specify)	0.00	0.0	0.00
Subtotal	611.46	9,151.8	0.47
Geothermal Heat Pumps	12,000.00	47,400.0	0.13
TOTAL	12,611.46	56,551.8	0.14

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2005 TO DECEMBER 31, 2009 (excluding heat pump wells)

[1] Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1]	(all)	50	0	50	0	25
Production	>150^o C	100	0	100	0	200
	150-100^o C	67	6	73	0	135
	<100^o C	0	4	4	0	4
Injection	(all)	20	0	20	0	40
Total		237	10	247	0	404

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2005	2	2	10	0	0	1200
2006	2	2	10	0	0	1200
2007	2	2	10	0	0	1000
2008	2	2	10	0	0	1000
2009	2	2	10	0	0	1500
Total	10	10	50	0	0	5900

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2009) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	N/A	N/A				
2000-2004	250	200	100	200	80	20
2005-2009	500	1000	2	500	95	5

TABLE 2A. GEOTHERMAL POWER PLANTS IN ALASKA

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2009[3)] GWh/yr	Total under Constr. or Planned MWe
Near Fairbanks, AK	CHENA HOT SPRINGS	2006	3		B	0.73	0.50	3.94	
Total						0.73	0.50	3.94	50-95

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 2B. GEOTHERMAL POWER PLANTS IN CALIFORNIA

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1]	Type of Unit[2]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2008[3] GWh/yr	Total under Constr. or Planned MWe
Sonoma	AIDLIN	1989	2		D	20	17	132.98	
Lake	BEAR CANYON	1988	2		D	20	14	115.66	
Sonoma	SONOMA	1983	1		D	72	42	341.54	
Lake	WEST FORD FLAT	1988	2		D	27	24	209.61	
Sonoma	McCABE	1971	2		D	106	78	681.68	
Sonoma	RIDGELINE	1972	2		D	106	69	600.71	
Sonoma	EAGLE ROCK	1975	1		D	110	66	512.84	
Sonoma	COBB CREEK	1979	1		D	110	52	389.22	
Lake	BIG GEYSERS	1980	1		D	97	48	435.64	
Sonoma	SULPHUR SPRINGS	1980	1		D	109	51	425.09	
Lake	QUICKSILVER	1985	1		D	113	53	424.56	
Sonoma	LAKE VIEW	1985	1		D	113	52	427.36	
Sonoma	SOCRATES	1983	1		D	113	50	406.35	
Lake	CALISTOGA	1984	1		D	80	66	555.13	
Sonoma	GRANT	1985	1		D	113	43	358.23	
The Geysers	NCPA I	1983	2		D	110	56	490.54	
The Geysers	NCPA II	1983	2		D	110	52	456.2	
Holtville	GEM RESOURCES II	1989	1		2F	18	9	82.46	
Holtville	GEM RESOURCES III	1989	1		2F	18	12	102.4	
IV	ORMESA I, IE, IH	1986, 1988,19	1		B	44	14	120.6	
IV	ORMESA IE	1988	1		B	10	5	41.69	
IV	ORMESA IH	1989	1		B	12	6	53.62	
IV	ORMESA II	1987	1		B	18	18	154.85	
IV	HEBER	1985	2		2F	52	37	324.1	
IV	HEBER II	1993	7		B	48	6	52.9	
IV	HEBER SOUTH	2008	1		B	10	0	0**	
Calipatria	SALTON SEA I	1982	1		2F	10	9	79.57	
Calipatria	SALTON SEA II	1990	3		2F	20	15	128.1	
Calipatria	SALTON SEA III	1989	1		2F	50	45	398.53	
Calipatria	SALTON SEA IV	1996	1		2F	40	39	343.61	
Calipatria	SALTON SEA V	2000	1		2F	49	40	350.23	
Calipatria	VULCAN	1986	1		2F	34	31	272.87	
Calipatria	DEL RANCH (HOCH)	1989	1		2F	38	37	322.18	
Calipatria	ELMORE	1989	1		2F	38	37	321.15	
Calipatria	LEATHER	1990	1		2F	38	39	345.89	
Calipatria	CE TURBO	2000	1		1F	10	8	71.55	
Amedee	AMEDEE	1988	2		B	1.6			
Coso	NAVY I	1987	3		2F	90	71	625.57	
Coso	NAVY II	1988	3		2F	90	66	578.54	
China Lake	BLM	1989	3		2F	90			
Sierra Nevada Mtns.-Mono	MAMMOTH PACIFIC I	1984	4		B	10	5	40.86	
Sierra Nevada Mtns.-Mono	MAMMOTH PACIFIC II	1990	3		B	15	11	93.25	
Sierra Nevada Mtns.-Mono	Ples	1990	3		B	15	12	102.31	
Wendel	HL POWER	1989	1		H	35.5			
IV	GOULD	2006	2		B	N/A			
	BOTTLE ROCK	2007			D	55	11	98.31	
Coso	Coso Energy Developers	1989	3		2F	90	56	489.67	
IV	SIGC Binary	1992	7		B	42			
	WINEAGLE		1			0.7			
Total						2620.8	1472	12558.15	1555-1939

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

**There is one unit at Heber that is dedicated specifically to parasitic load this would account for some MW not being delivered to the grid and therefore not reported to the CEC DOGGR.

TABLE 2C. GEOTHERMAL POWER PLANTS IN HAWAII

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2009[3)] GWh/yr	Total under Constr. or Planned MWe
Pahoa	PUNA	1993	10		H, 2F and B	35	30	236.52	
Total						35	30	236.52	8

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 2D. GEOTHERMAL POWER PLANTS IN IDAHO

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2009[3)] GWh/yr	Total under Constr. or Planned MWe
Malta	RAFT RIVER	2007			B	15.8	11.5	90.67	
Total						15.8	11.5	90.67	238-326

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 2E. GEOTHERMAL POWER PLANTS IN NEVADA

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2008[3)] GWh/yr	Total under Constr. or Planned MWe
Beowawe	BEOWAWE	1985	1		2F	16.6	14.75	129.21	
Churchill	BRADY HOT SPRINGS	1992	3		2F, B	27	13.98	122.47	
Churchill	DESERT PEAK I **	1985	2	R	2F	9.9			
Churchill	DESERT PEAK II	2006	1		B	23	12.15	106.45	
Caithness Dixie Valley	DIXIE VALLEY	1988	1		2F	67.2	48.67	426.34	
Fallon	SODA LAKE I ***	1987	4		B	5.1	1.14	9.95	
Fallon	SODA LAKE II	1990	6		B	21	9.58	83.92	
Washoe	STEAMBOAT I ****	1986	7		B	8.4	0.00		
Washoe	STEAMBOAT IA	1988	2		B	2.95	0.03	0.3	
Washoe	STEAMBOAT II	1992, upgrade 2006	2		B	29	10.71	93.8	
Washoe	STEAMBOAT III	1992	2		B	24	12.98	113.7	
Fallon	STILLWATER *****	1989	1		B	21	7.41	64.92	
Wabuska	WABUSKA	1984	3		B	2.2	1.23	10.79	
Reno	STEAMBOAT HILLS	1988	1		1F	14.41	8.56	74.98	
Reno	GALENA (used to be Richard Burdette)	2005	2		B	30	23.39	204.94	
Reno	GALENA 2	2007	1		B	15	9.81	85.97	
Reno	GALENA 3	2008	1		B	20	22.55	197.52	
San Emidio	SAN EMIDIO (EMPIRE)	1987	4		B	4.8	3.42	29.95	
Fallon	SALT WELLS	2009			B	18.6			
Fallon	STILLWATER II	2009			B	47.3			
Humboldt	BLUE MOUNTAIN FAULKNER I	2009			B	50			
Total						447.56	200.36	1755.21	1776-3323

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced; gross production MWh taken from Nevada Bureau of Mines and Geology 2008 report.

**Desert Peak II is a new binary power plant that was built to replace the original steam turbine power plant at Desert Peak, which was permanently shut down on May 1, 2006. The new power plant came on-line on August 1, 2006 with a generation capacity of 23 MW, more than twice that of the original power plant.

***Difference from a larger aggregate number from IGA 2005 for the two soda lake plants

****SB Geo, Inc. and Ormat started decommissioning the Steamboat I plant

TABLE 2F. GEOTHERMAL POWER PLANTS IN NEW MEXICO

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash; 2F = Double Flash; 3F = Triple Flash; D = Dry Steam; B = Binary (Rankine Cycle); H = Hybrid (explain); O = Other (please specify)

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2009[3)] GWh/yr	Total under Constr. or Planned MWe
Hidalgo, County	LIGHTNING DOCK	2008	1		B	0.24	0.15	0.54	
Total						0.24	0.15	0.54	20

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 2G. GEOTHERMAL POWER PLANTS IN OREGON

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash; 2F = Double Flash; 3F = Triple Flash; D = Dry Steam; B = Binary (Rankine Cycle); H = Hybrid (explain); O = Other (please specify)

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2009[3)] GWh/yr	Total under Constr. or Planned MWe
Klamath Falls	OIT 1	2009	1		B	0.28	0.15	0.11	
Total						0.28	0.15	0.11	317-368

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 2H. GEOTHERMAL POWER PLANTS IN UTAH

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2009[3)] GWh/yr	Total under Constr. or Planned MWe
Roosevelt Hot Springs; near Milford	BLUNDELL I	1984			1F	26	23	228.90	
Roosevelt Hot Springs; near Milford	BLUNDELL II	2007			B	11	10	99.52	
Beaver County	THERMO I	2009	50		B	10	NA	0	
Total						47	33	328.42	272-332

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 2I. GEOTHERMAL POWER PLANTS IN WYOMING

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2009[3)] GWh/yr	Total under Constr. or Planned MWe
Casper	RMOTC-GHCG	2008	1		B	0.25	0.15	0.48	
Total						0.25	0.15	0.48	0

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.