

Careers in Geothermal Energy

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September 2012 — Report 9

In the search for new energy resources, scientists have discovered ways to use the Earth itself as a valuable source of power. Geothermal power plants use the Earth's natural underground heat to provide clean, renewable energy.

As far back as the 1800s, people extracted water from geothermal hot springs to use in homes or businesses. However, it wasn't until 1960 that the first large-scale geothermal electricity generation plant began operating in the United States, at The Geysers in California.

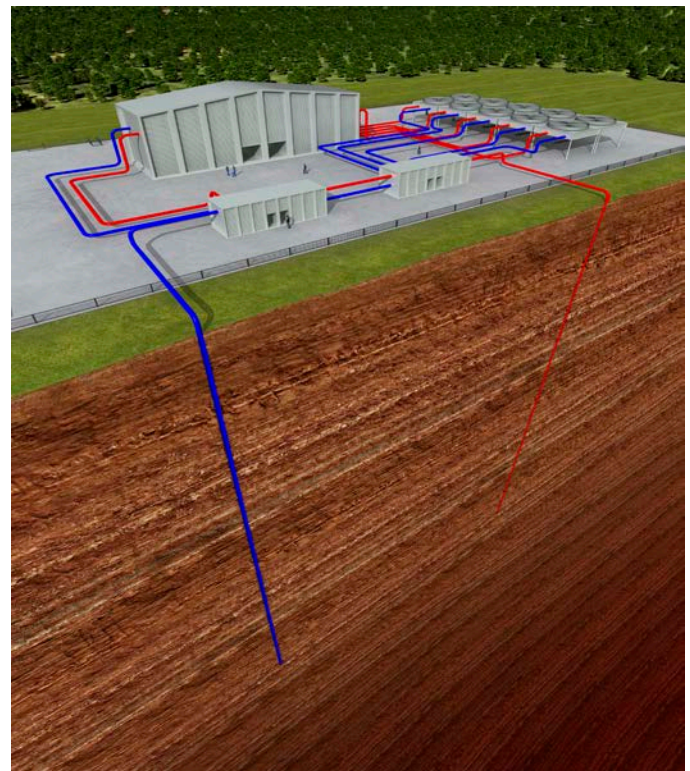
Today, the United States has approximately 3,187 megawatts of installed geothermal generating capacity, more than any other country in the world.¹ Despite this capacity, geothermal power is only a small provider of energy. In 2010, geothermal energy accounted for 3 percent of renewable energy-based electricity consumption in the United States, less than that from biomass, hydroelectric, and wind sources.²

Although still a small contributor to the power needs of the United States, geothermal is an attractive energy source. Geothermal power plants can provide baseload power, which means that the power they generate does not vary. This distinguishes geothermal from other renewable sources, such as solar and wind, which only produce power when sunlight or wind are sufficiently steady and strong.

Despite its potential for providing clean and steady energy, however, geothermal power development faces challenges. Geothermal projects are expensive, and it takes years to build a working geothermal plant. The high cost can discourage investment by private industry. Another challenge limiting development of

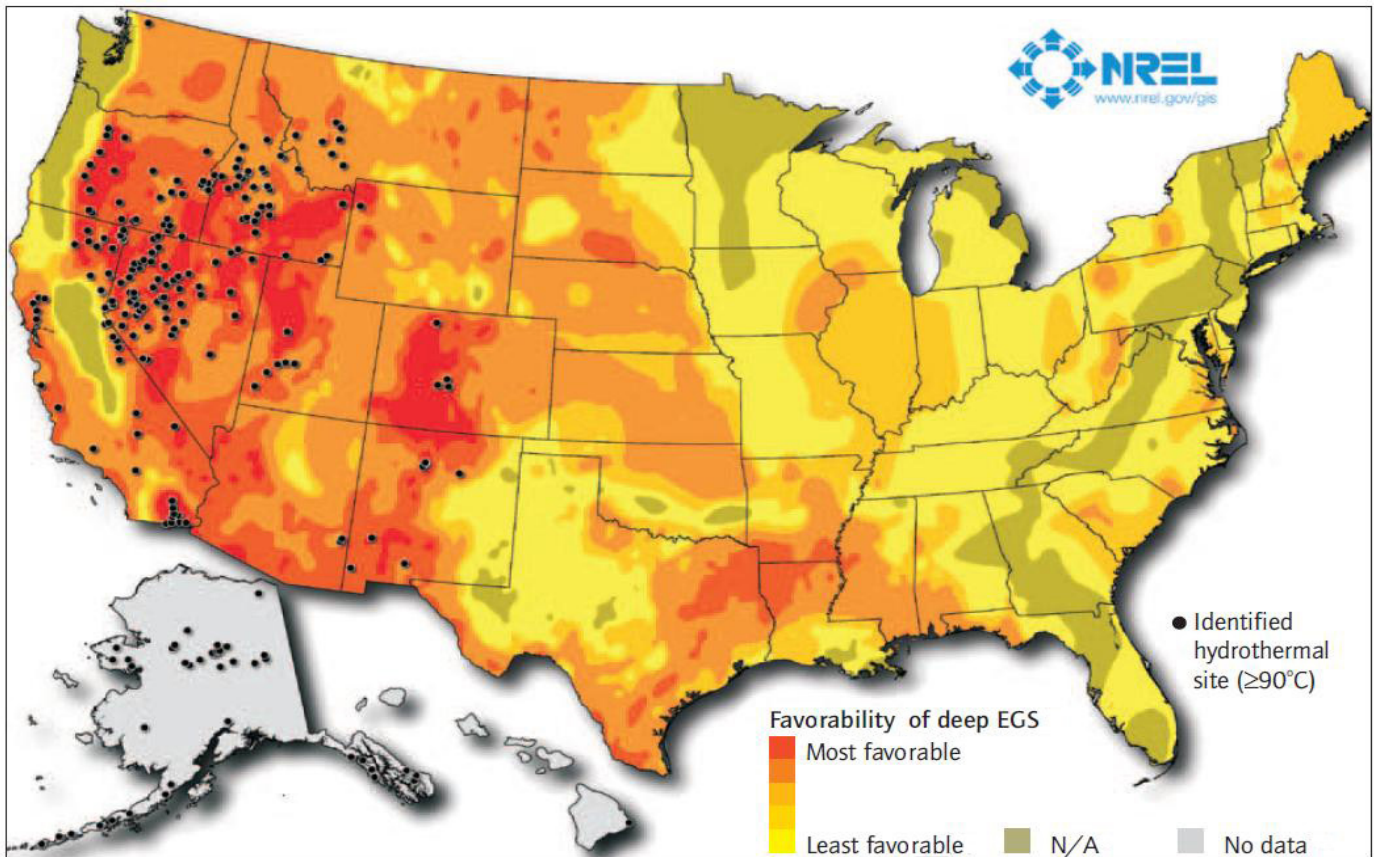
geothermal energy is the fact that geothermal plants are often located in remote areas. Roads must be built to the plant sites, and transmitting electricity from the plant to distant consumers requires the construction of transmission infrastructure such as high-voltage power lines. Location is therefore a consideration for those seeking employment in geothermal energy.

Despite these challenges, U.S. geothermal energy production is expected to grow. In 2012, the geothermal industry is developing 130 geothermal projects in 15 states, according to the Geothermal Energy Association (GEA).³ As geothermal technologies become more cost-effective



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Map 1. Geothermal Resources of the U.S.: Locations of hydrothermal sites and favorability of deep Enhanced Geothermal Systems (EGS)



Source: National Renewable Energy Laboratory, www.nrel.gov/gis

in comparison to other power sources, more development might occur.

The Bureau of Labor Statistics (BLS) released the first results of its Green Goods and Services (GGS) survey in 2012. GGS jobs are those associated with producing environmentally beneficial green goods and services. The survey found that there were about 620 GGS private sector workers in geothermal energy production in the United States in 2010.⁴ These data do not include government workers or workers employed in other industries, such as utility system construction, engineering services, or scientific research and development services, that work on geothermal projects. These industries have separate GGS employment estimates, which include those who work on both geothermal and other projects.

The GEA estimated that there were about 5,200 jobs directly related to geothermal power production and management in 2010.⁵ Unlike the GGS data, this GEA estimate includes workers in many different industries. The GEA estimates that developing a 50-megawatt geothermal plant requires between 697 and 862 workers.⁶

As seen in map 1, there is potential for geothermal energy development throughout the United States. The most accessible geothermal sites are concentrated in the Western United States, where most geothermal development has already taken place. Jobs in geothermal energy are usually located near these sites.

This article provides information on various career opportunities in geothermal energy. The first section is an overview of geothermal plant operation, and the second section discusses the different steps necessary to construct a geothermal plant. The other sections detail occupations that are critical to the geothermal industry. Each occupational profile includes information on job duties; the credentials needed to work in these occupations, such as education, training, certification, and licensure; and wage data.

How geothermal power works

Geothermal power uses heat generated by the Earth’s core to provide energy. This heat can be captured and used on

both a residential and utility scale. Residential geothermal uses water running through underground pipes (called geothermal heat pumps) to regulate a building's internal temperature. In winter, the water in these pipes carries heat from the Earth into the building. In summer, the geothermal system carries excess heat out of the building. Although geothermal heat pumps are growing in popularity, this article focuses on utility-scale geothermal projects, which use geothermal plants to generate electricity for the power grid.

Utility-scale geothermal projects get energy from groundwater found deep in underground cracks and reservoirs. In places where the Earth's natural heat has brought these underground reservoirs to temperatures of 225 to 600 degrees Fahrenheit (107 to 315 degrees Celsius), the groundwater can be used to power a geothermal plant.

There are three common types of geothermal power plants: dry steam, flash steam, and binary cycle.

Dry steam plants are the simplest and most common.⁷ They rely on steam released from underground sources to turn turbines and generate electricity. Although dry steam plants are simple to operate, they are restricted by the relatively few locations that produce sufficient steam for a utility-scale plant.

Flash steam geothermal plants mine hot water through

long pipes that extend into deep underground reservoirs, where extreme pressure allows water to remain in a liquid state above its surface boiling point. The water, usually at temperatures of more than 360 degrees Fahrenheit, is piped up to holding tanks. When the high-pressure hot water enters these low-pressure tanks, it becomes steam. Then, in dry steam plants, this steam powers turbines to generate electricity.

In a *binary cycle* plant, hot water is also piped from underground reservoirs, but then a different fluid, with a lower boiling temperature than water, captures the water's heat through a heat exchanger. The vapor from this other fluid is used to turn the plant's turbines and generate electricity. A binary cycle plant can operate in an area with geothermal fluid temperatures of 225 to 360 degrees Fahrenheit (107 to 182 degrees Celsius), lower than the temperature required of the other plants.

Geothermal plants release the cooled water back into the ground, where it seeps back into the underground reservoir, is reheated by the earth, and can be reused by the plant.

Through this full cycle, geothermal power provides a renewable and inexhaustible source of energy.



Building and maintaining a geothermal plant

Geothermal energy plants must be located near sufficient hot groundwater. Scientists analyze charts, satellite imagery, and seismic studies to find appropriate underground reservoirs. After locating a promising area and analyzing the terrain, workers drill exploratory wells to verify a site's suitability.

For flash steam and binary cycle plants, geothermal drilling projects require machinery and workers similar to those used in drilling projects in the oil and gas industry. Drilling is extremely expensive, and poses a huge risk of financial loss if sites are unsuitable. For example, because geothermal wells are thousands of feet deep, unexpected layers of hard rock can add significant cost to a drilling project.

After an underwater reservoir is found, groundwater is pumped up to the surface, where scientists analyze it to determine its suitability for a geothermal plant. This initial phase—locating and drilling exploratory wells—usually takes several years to complete.



After determining the best location from which to tap the underground reservoir, workers drill the main well. Many geothermal companies hire specialized drilling firms to do this work. As drillers penetrate the underground reservoir, they install pipes in the well to carry the groundwater up to the surface. Drilling pipes may also carry byproducts, such as mud, up to the surface, where they are hauled offsite for disposal.

As the main well is completed, construction crews build the geothermal plant. They use heavy equipment to clear the land and lay the plant's foundation. Electricians install a power plant's electrical components, while pipefitters build the pipe infrastructure to carry the hot groundwater and steam through the geothermal plant. In addition to the plant itself, construction crews build roads and transmission lines.

After a geothermal plant has been constructed and connected to the power grid, it is ready to become operational. A plant operator and technicians remain on-site to monitor the plant and resolve any problems. Because geothermal energy provides a stable source of power, plants operate more efficiently and is less labor intensive than other energy-generating plants.

Occupations in geothermal energy

It requires many workers to get a geothermal plant up and running. Different workers are needed for each phase of a geothermal plant's development.

The occupations detailed in this section are not specific to the geothermal industry. For many occupations, workers' experiences in industries other than geothermal can be applied to geothermal projects.

Science occupations

Scientific research is an important component of geothermal development. Because drilling wells is extremely expensive, it's important that scientists select drilling sites most likely to support geothermal power.

Scientists work in offices where they study charts and maps of geothermal resources. They might also travel to the field to examine proposed geothermal sites. Scientists work on teams with other scientists in various disciplines. Geothermal companies employ some scientists full-time, while others are hired as consultants.

Environmental scientists work with geothermal plant developers to help them comply with environmental regulations and policies and to ensure that sensitive parts of the ecosystem are protected. They use their knowledge of the natural sciences to minimize hazards to the health of the environment and the nearby population. These scientists produce environmental impact studies necessary for a geothermal project to earn its building permits.

Geologists spend a large part of their time in the field, identifying and examining the topography and geologic makeup of a geothermal site. Geologists also study maps and charts to ensure that a site will be able to supply adequate geothermal energy. Geologists use their knowledge of different kinds of rock to make recommendations on the most cost-effective areas to drill. Some specialized geologists might help to monitor a plant’s location for seismic activity and attempt to predict the threat of earthquakes.

Hydrologists study water and the water cycle. They study the movement, distribution, and other properties of water, and analyze how these properties influence the surrounding environment. Hydrologists use their expertise to solve problems concerning water quality and availability. On geothermal projects, hydrologists study the water below the earth’s surface. They help decide where to drill wells and analyze the groundwater that is pumped from the underground reservoirs to the surface.

Wildlife biologists evaluate a geothermal plant’s effect on local animal life. Although geothermal plants are not inherently destructive, construction of the related infrastructure, such as plants, roads, and transmission towers, can be disruptive to the natural environment. Biologists ensure that the plant’s impact on local animal populations is minimal. They spend a great deal of their time outdoors at the site, cataloging the surrounding wildlife and making recommendations on how to avoid interfering with local ecosystems.

Credentials

Although a master’s degree is often preferred, a bachelor’s degree, depending on the specialty, is typically sufficient for an entry-level position for geologists, environmental scientists, and wildlife biologists. Hydrologists typically enter the occupation with a master’s degree. A Ph.D. is

desirable for scientists who oversee environmental impact and site suitability studies.

Most scientists must have excellent computer skills because they use computers frequently for data analysis, digital mapping, remote sensing, and computer modeling. Scientists in certain specialties, such as geologists, are usually certified or licensed by a state licensing board.

Wages

BLS does not currently have wage data specific to the geothermal industry. However, BLS does have wage data for the electric power generation, transmission, and distribution industry group. The table that follows shows BLS data for the science occupations in this industry group for May 2011. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected science occupations	Median annual wages, May 2011 ¹
Environmental scientists and specialists, including health	\$87,160
Geoscientists, except hydrologists and geographers	77,460
Hydrologists ²	75,680
Zoologists and wildlife biologists ²	57,420

¹ Occupational Employment Statistics data are available at www.bls.gov/oes. The data do not include benefits.
² Wage data for hydrologists and zoologists and wildlife biologists are not available for the electric power generation, transmission, and distribution industry group. The data here represent wages for the occupation as a whole.

Engineering occupations

Designing geothermal plants or new drilling equipment requires the work of many engineers. Most work in offices, laboratories, or industrial plants, but some engineers work outdoors at construction sites, where they monitor or direct operations or solve onsite problems.

Civil engineers design geothermal plants and supervise the construction phase. Many geothermal plants are built in rocky, difficult terrain, which require special procedures. Civil engineers also have to consider potential hazards such as earthquakes, and build plants to withstand

them. These engineers are also responsible for designing access roads that lead to the plants.

Electrical engineers design, develop, test, and supervise the manufacture of geothermal plants' electrical components, including machinery controls, lighting and wiring, generators, communications systems, and electricity transmission systems.

Electronics engineers are responsible for systems that control plant systems or signal processes. Electrical engineers work primarily with power generation and distribution; electronics engineers develop the complex electronic systems used to operate the geothermal plant.

Environmental engineers deal with the potential environmental impacts of geothermal plants. Although geothermal energy is an environmentally friendly source of electricity, environmental engineers must consider a site's potential impact on local plants and wildlife.

Mechanical engineers research, design, develop, and test tools and a variety of machines and mechanical devices.



Many of these engineers supervise the manufacturing processes of drilling equipment or various generator or turbine components.

Credentials

Engineers typically have at least a bachelor's degree in an engineering specialty. However, some jobs require more education, such as a master's degree or doctoral degree. Additionally, an engineer typically must be licensed as a professional engineer (PE) and is expected to complete continuing education to keep current with new technologies.

Entry-level engineers may also be hired as interns or junior team members and work under the close supervision of more senior engineers. As they gain experience and knowledge, they are assigned more difficult tasks and given greater independence.

Engineers are usually required to be certified as competent to carry out specific work, depending on the systems used by a particular geothermal power company.

Wages

BLS does not currently have wage data specific to the geothermal industry. However, BLS does have wage data for the electric power generation, transmission, and distribution industry group. The table that follows shows BLS data for the engineering occupations in this industry group for May 2011. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected engineering occupations	Median annual wages, May 2011 ¹
Civil engineers	\$84,950
Electrical engineers	84,730
Electronics engineers, except computer	90,790
Environmental engineers	79,530
Mechanical engineers	82,230

¹ Occupational Employment Statistics data are available at www.bls.gov/oes. The data do not include benefits.

Drilling occupations

To reach hot water far below the earth's surface, geothermal plants use wells that descend thousands of feet into underground reservoirs. Drilling these wells requires



specialized machinery and workers. Drilling crews first drill exploratory wells to confirm the locations of underground reservoirs. After discovering the best locations, they drill the geothermal plant's main well.

Drilling crews typically use a derrick, a large, metal-framed crane hanging over a well, to guide drilling equipment. Because drilling equipment is so heavy, derricks are necessary to control and maneuver drilling bits, pipes, and other equipment. Drilling fluids that help to break up the rock are pumped into the well through a pipe connected to the drill bit. The pipe also carries debris and mud out of the well and to the surface, where it can be disposed of. As the well gets deeper, new pipe sections are connected to those already in the ground, and the drill continues until it taps the underground reservoir.

Depending on a project's location and the type of rock that needs to be drilled through, drilling crews will use different drill bits and drill fluid mixtures.

In addition to the workers who drill the wells, drilling crews might include some support personnel, such as workers who transport the drilling rigs and fuel to project sites.

Derrick operators control and inspect drilling derricks. These workers can raise or lower the drill bits and pipes

into or out of the well. Derrick operators are also responsible for maintaining their machinery and ensuring that it operates correctly.

Rotary driller operators control the drill itself. They determine a drill's pressure and speed as it penetrates rock. To keep drill sites safe, rotary driller operators use gauges that monitor drill pump pressure and other data, such as how much drill mud and debris are being pumped from the well. Rotary drill operators also keep records of where they've drilled and how many layers of rock they've penetrated.

Roustabouts do much of the basic labor on drilling sites. They clean equipment and keep work areas free of the debris and drilling mud that the drill pipes carry up from the wells. Roustabouts also install new pipe sections that allow the drill to reach deeper underground.

Credentials

There are few formal education requirements for drilling crew workers. Although drilling crew workers are not required to have a high school diploma, some employers might prefer to hire workers who do. While in

school, drilling crew workers can learn skills such as basic mechanics, welding, and heavy equipment operations through vocational programs.

Most drilling crew workers start as helpers to experienced workers and are trained on the job. However, formal training is becoming more common as new and more advanced machinery and methods are used. Drilling crew workers usually must be at least 18 years old, be in good physical condition, and pass a drug test.

Wages

BLS does not currently have wage data specific to the geothermal industry. However, BLS does have wage data for drilling crew workers across all industries. The table that follows shows BLS data for drilling occupations in May 2011. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected drilling occupations	Median annual wages, May 2011 ¹
Derrick operators, oil and gas	\$45,220
Rotary drill operators, oil and gas	51,310
Roustabouts, oil and gas	32,980

¹ Occupational Employment Statistics data are available at www.bls.gov/oes. The data do not include benefits.

Construction occupations

Construction workers build the geothermal power plant and necessary supporting infrastructure, such as roads and transmission lines. During the construction phase, crews have to build around the geothermal well and drilling operations. Depending on where a plant is located, construction crews might operate specialized equipment to build plants in rocky, difficult terrain.

Carpenters build, install, and repair any fixtures made from wood or other materials, including plastic, fiberglass, and drywall, on geothermal construction sites. Following construction drawings, carpenters measure, mark, and arrange their materials. They use hand and power tools, such as planes, saws, and drills, to cut and shape the materials, which are frequently joined together with nails, screws, or other fasteners. After completing an installation, carpenters check the accuracy of their work with

instruments, such as levels or rulers, before making any necessary adjustments.

Construction equipment operators use machinery to clear earth, trees, and rocks at geothermal plant construction sites. They also use machines to grade the land and build roads prior to construction. Construction equipment operators use their machinery to hoist heavy construction materials for other workers to use.

Construction laborers perform a wide range of tasks on geothermal plant construction sites. They use a variety of equipment, including jackhammers and small mechanical hoists. For some jobs, construction laborers use computers and other high-tech input devices to control robotic pipe cutters and cleaners. They often assist workers in the specialty trades, such as carpenters and electricians.

Construction managers plan, direct, coordinate, and budget geothermal projects. They may supervise an entire project or, depending on the size of a plant, just part of one. As coordinators of all design and construction processes, construction managers select, hire, and oversee specialty trade contractors, such as carpenters and electricians.

Construction managers are involved in a plant's development from its original conceptual designs through its final construction. They help to ensure that geothermal plants are built on time and within budget. Construction managers often meet with engineers, architects, and any other workers building the plant.

Electricians do both installation and maintenance work on the energy systems of geothermal plants. When constructing plants, electricians check their construction drawings to determine where to place equipment such as circuits and outlets. After finding the proper locations, they install and connect wires to systems such as circuit breakers, transformers, and outlets.

Electricians also install the electrical equipment and wiring that connects the geothermal plant to the electrical grid. They must be familiar with computer systems that regulate the flow of electricity and be experienced working with high-voltage systems.

Plumbers, pipefitters, and steamfitters install, maintain, and repair the pipe systems in geothermal plants that carry hot, high-pressure fluids from the well and into low-

pressure tanks. They also are responsible for a plant’s other pipes, including those that carry steam from the tanks to the turbines.

Plumbers, pipefitters, and steamfitters must frequently lift heavy pipes, stand for long periods of time, and work in uncomfortable and cramped positions. In their work, they face a number of possible hazards, including falls from ladders, cuts from sharp objects, and burns from hot pipes or soldering equipment.

Credentials

Construction managers have typically completed an associate’s degree or higher in construction management, business management, or engineering. They also usually have previous experience working on construction projects. Because experience is so important for construction managers, in some cases, it may be substituted for educational requirements. However, large, complex projects such as a geothermal plant require specialized education. Workers with degrees in construction management or engineering, but without significant experience, may be hired as assistants to project managers.

Most construction laborers are trained on the job. Laborers typically work under a foreman, who gives them instructions. As they gain more experience and prove their abilities, laborers may become foremen themselves.

Equipment operators typically enter the occupation with a high school diploma or equivalent. They may learn on the job, complete a formal training program, or a combination of both. Certain equipment requires operators to be certified, which involves some training and testing to ensure competence and safety.

Electricians, carpenters, plumbers, pipefitters, and steamfitters typically enter the occupation with a high school diploma or equivalent. They are usually trained through apprenticeship programs, which typically last 3 or 4 years for electricians and carpenters and 4 or 5 years for plumbers, pipefitters, and steamfitters. Electricians, carpenters, plumbers, pipefitters, and steamfitters may also attend specialized training programs on the specific systems with which they work.

Wages

BLS does not currently have wage data specific to the geothermal industry. However, BLS does have wage data for the electric power generation, transmission, and distribution industry. The table that follows shows BLS data for the construction occupations in this industry group for

May 2011. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected construction occupations	Median annual wages, May 2011 ¹
Carpenters	\$58,000
Operating engineers and other construction equipment operators	57,630
Construction laborers	43,480
Construction managers	95,630
Electricians	60,310
Plumbers, pipefitters, and steamfitters	68,800

¹ Occupational Employment Statistics data are available at www.bls.gov/oes. The data do not include benefits.

Plant operators

After a geothermal plant is completed and running, some staff are needed to operate and monitor the plant. They prevent or resolve any problems that would stop the plant from operating correctly.

Power plant operators work in control rooms to monitor power generation and distribution at a geothermal plant. They monitor the geothermal plant’s pipes, generators, and instruments that regulate voltage and electricity flows. Power plant operators communicate with electrical distribution centers on the regional power grid to match production with system load. They go on inspection rounds to confirm that everything in the plant is operating correctly and keep records of switching operations as well as loads on generators, lines, and transformers. Power plant operators use computers to report unusual incidents, malfunctioning equipment, or maintenance performed during their shifts.

Credentials

Power plant operators typically need a high school diploma or equivalent and on-the-job training. Previous work experience, such as a line worker or a laborer in a power plant, can be helpful in getting a job. Strong mechanical, technical, and computer skills are needed to operate a power plant. Certification by the North American Energy Reliability Corporation (NERC) is necessary for positions that could affect the power grid. Companies also require individuals seeking highly technical jobs to have a strong math and science background.

Wages

BLS does not currently have wage data specific to the geothermal industry. However, BLS does have wage data for the electric power generation, transmission, and distribution industry group, which includes the operation of geothermal plants. Power plant operators in this industry group earned a median annual wage of \$66,340 in May 2011. The wages are for the United States as a whole; wages vary by employer and location.

Conclusion

Geothermal jobs of all kinds will be most prevalent in the western United States, where geothermal projects are most common. If the geothermal industry continues to grow, opportunities should arise for workers in a wide variety of occupations with different education and training requirements, from doctoral scientists to roustabouts. Some occupations, such as those in construction, typically require workers to have completed an apprenticeship, and others have less formal on-the-job training. As the demand for clean energy grows, jobs in geothermal energy will be a small but growing potential source of new employment opportunities.



Notes

¹ *Annual U.S. Geothermal Power Production and Development Report* (Geothermal Energy Association, April 2012), p. 6, http://www.geo-energy.org/reports/2012/AnnualUSGeothermalPowerProductionandDevelopmentReport_Final.pdf.

² *Ibid*, p. 6

³ *Ibid*, p. 9

⁴ Green Goods and Services (GGS) Survey (U.S. Bureau of Labor Statistics, 2012), <http://www.bls.gov/ggs>.

⁵ *Green Jobs Through Geothermal Energy* (Geothermal Energy Association, October 2010), p. 6, http://www.geo-energy.org/pdf/reports/GreenJobs_Through_Geothermal_Energy_Final_Oct2010.pdf.

⁶ *Ibid*, p. 10.

⁷ *Annual Geothermal Power Production and Development Report*, p. 7.