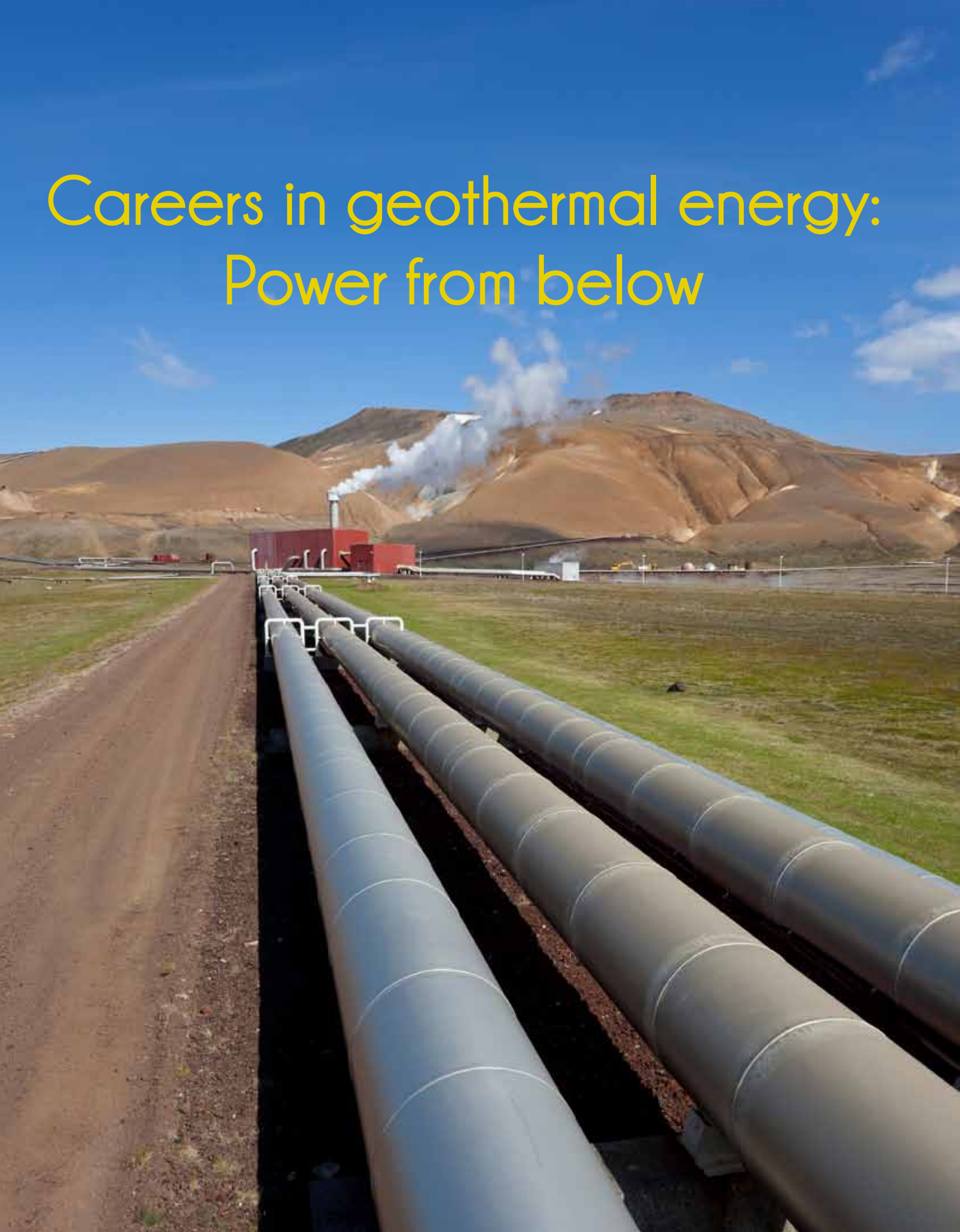
Careers in geothermal energy: Power from below



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.

The geothermal energy industry has expanded rapidly in recent years as interest in renewable energy has grown. In 2011, the U.S. Bureau of Labor Statistics (BLS) counted about 1,050 jobs in geothermal power generation. And the Geothermal Energy Association estimates that there were about 5,200 jobs directly related to geothermal power production and management in the United States in 2010.

Geothermal energy production is expected to continue to grow, and with it the demand for workers in associated occupations. In 2012, the geothermal industry was developing 130 geothermal projects in 15 states, according to the association.

This article describes geothermal energy and career opportunities in the industry, focusing on geothermal projects that generate electricity for power grids. The first two sections explain geothermal energy and how it works, and the third section discusses the different steps necessary to construct a geothermal plant. The fourth section highlights occupations that are critical to the geothermal industry. Each occupational overview includes information on job duties; occupational wage and employment data; and the credentials needed to work in these occupations, such as education, training, certification, and licensure. Sources for more information are listed at the end of the article.

Underground power: The background

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

Drew Liming

Today, the United States has more geothermal generating capacity than any other country in the world. Despite this, geothermal energy accounted for only 3 percent of renewable energy-based electricity consumption in 2010.

Geothermal may be a small part of power generation in the United States, but it's an attractive energy source. Geothermal power plants 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 produce power only when sunlight or wind are sufficiently steady and strong.

Despite its potential as a clean, steady energy source, geothermal power faces challenges in expanding development. Geothermal projects are expensive, and it takes years to build a working geothermal plant. In addition, geothermal plants are often located in remote areas. The most accessible geothermal sites

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are concentrated in the Western United States, so jobs that involve working with geothermal energy are usually located near these sites.

How does geothermal power work?

Geothermal energy uses groundwater that has been heated in cracks and reservoirs deep in the Earth's core. This heat can be captured and used as residential or utility power.

Residential geothermal power uses water running through underground pipes 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 pipes carry excess heat out of the building.

Utility geothermal power uses energy from heated groundwater to generate electricity. The occupations discussed in this article are usually associated with utility-scale geothermal projects. 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. They rely on steam released from underground sources to turn turbines and generate electricity.

Flash steam plants mine hot water through long pipes that extend into deep underground reservoirs. The water is piped up to holding tanks. When the high-pressure hot water enters these low-pressure tanks, it becomes steam. This steam powers turbines to generate electricity.

In a *binary cycle* plant, hot water is piped from underground reservoirs, but a different fluid with a lower boiling point is used to capture the water's heat through a heat exchanger. The vapor from this other fluid turns the plant's turbines and generates electricity.

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

Building 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. Workers then drill exploratory wells to

verify a site's usability. After an underwater reservoir is found, groundwater is pumped up to the surface, where scientists analyze it to determine its suitability.

Workers determine the best location from which to tap the underground reservoir and then drill the main well. 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 risk of huge financial loss if sites are unsuitable. Many geothermal companies hire specialized drilling firms to do this work. Once drillers reach the underground reservoir, they install pipes in the well to carry the groundwater up to the surface.

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

The geothermal plant becomes operational once it has been constructed and connected to the power grid. A plant operator and technicians remain on site to monitor the plant and resolve problems. Because geothermal energy is a stable source of power, these plants operate more efficiently and use less labor than other types of plants.

Working with geothermal energy

Many different types of workers are needed for each phase of a geothermal plant's development. The occupations highlighted in this section are not specific to the geothermal industry. Often, workers' experiences in other industries are applicable to geothermal projects.

Science occupations

Scientific research is an important component of geothermal development. Scientists study maps of geothermal resources and might also visit potential geothermal sites. They often work on teams with other scientists in various disciplines. Geothermal companies employ some scientists full-time and hire others 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. These workers use their knowledge of the natural sciences to minimize hazards to the health of the environment and the nearby population. They also prepare the environmental impact studies that are needed for a geothermal project to secure 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. They also study maps 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 the movement, distribution, and other properties of water and analyze how these properties influence the surrounding environment. Hydrologists use their expertise to solve problems that relate to 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. Geothermal plants are not inherently destructive, but construction of the related infrastructure—such as plants, roads, and transmission towers—can disrupt the natural environment. Biologists ensure that the plant's impact on local animal populations is minimal. They spend a lot of time outdoors at the site, cataloging the surrounding wildlife and recommending how to avoid interfering with local ecosystems.

Employment and wages. BLS does not currently have occupational wage or employment data specific to the geothermal industry. However, BLS does have these data for the electric power generation, transmission, and distribution industry group, which includes the operation of geothermal plants. Table 1 shows May 2011 BLS employment and wage data for the science occupations in this industry group.

Preparation. Employers often prefer that geologists, environmental scientists, and wildlife biologists have a master's degree. Depending on the specialty, however, a bachelor's degree is typically sufficient for an entry-level position in these disciplines. Hydrologists typically enter the occupation with a master's degree. A Ph.D. is recommended for scientists who oversee environmental impact and site suitability studies.

Excellent computer skills are a must for scientists because they use computers frequently for data analysis, digital mapping, remote sensing, and computer modeling. Some scientists, such as geologists, are usually certified or licensed by a state licensing board.

Engineering occupations

Designing geothermal plants or new drilling equipment requires the skills of engineers.

Table 1: Employment and wages in selected science occupations in the electric power generation, transmission, and distribution industry, May 2011

Occupations	Employment	Median annual wages
Environmental scientists and specialists, including health	1,200	$87,160
Geoscientists, except hydrologists and geographers	60	77,460
Hydrologists*	6,960	75,680
Zoologists and wildlife biologists*	18,380	57,420

* Industry-specific data are not available for this occupation. These data represent employment and wages for the occupation as a whole.

Source: U.S. Bureau of Labor Statistics, Occupational Employment Statistics.

Most engineers work in offices, laboratories, or industrial plants, but some work outdoors at construction sites, where they monitor or direct operations or solve problems at the site.

Civil engineers design geothermal plants and supervise the construction phase. Many geothermal plants are on rocky, difficult terrain, which require special procedures to build. 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 manufacturing of geothermal plants' electrical components, including machinery controls, lighting, wiring, generators, communications systems, and electricity transmission systems.

Electronics engineers are responsible for electrical components 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 generator or turbine components.

Employment and wages. BLS does not currently have occupational wage or employment data specific to the geothermal industry. However, BLS does have data for the electric power generation, transmission, and distribution industry group, which includes the operation of geothermal plants. Table 2 shows May 2011 BLS employment and wage data for the engineering occupations in this industry group.

Preparation. Engineers typically have at least a bachelor's degree in an engineering specialty. However, some jobs require more education, such as a master's or doctoral degree. Additionally, an engineer typically must be licensed as a professional engineer

Table 2: Employment and wages in selected engineering occupations in the electric power generation, transmission, and distribution industry, May 2011

Occupations	Employment	Median annual wages
Civil engineers	1,400	$84,950
Electrical engineers	15,310	84,730
Electronics engineers, except computer	400	90,790
Environmental engineers	560	79,530
Mechanical engineers	920	82,230

Source: U.S. Bureau of Labor Statistics, Occupational Employment Statistics.

and must complete continuing education to keep current with new technologies.

Entry-level engineers may be hired as interns or junior team members to 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.

Drilling occupations

To reach hot water far below the earth's surface, geothermal plants use wells that descend 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. 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 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 also maintain their machinery and ensure that it operates correctly.

Rotary drill 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.

Employment and wages. BLS does not currently have occupational wage or employment data specific to the geothermal industry. However, BLS does have data for drilling crew workers across all industries. Table 3 shows May 2011 BLS employment and wage data for drilling occupations.

Preparation. There are few formal educational requirements for drilling crew workers, but employer preferences vary. For example, although drilling crew workers are not required to have a high school diploma, some employers might prefer to hire workers who do. Drilling crew workers can enroll in vocational programs to learn skills such as basic mechanics, welding, and heavy equipment operations.

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

Construction occupations

Construction workers build the geothermal power plant and necessary supporting infrastructure, such as roads and transmission lines. 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 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 before construction starts. Construction

Table 3: Employment and wages in selected drilling occupations, all industries, May 2011

Occupations	Employment	Median annual wages
Derrick operators, oil and gas	19,480	$45,220
Rotary drill operators, oil and gas	21,650	51,310
Roustabouts, oil and gas	51,540	32,980

Source: U.S. Bureau of Labor Statistics, Occupational Employment Statistics.

equipment operators use their machinery to hoist heavy construction materials for other workers to use.

Construction laborers do many 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 carpenters, electricians, and other specialty trades workers.

Construction managers plan, direct, coordinate, and budget geothermal projects. They may supervise an entire project or, depending on the size of a plant, part of one. As coordinators of the design and construction processes, construction managers select, hire, and oversee specialty trades workers, 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 other workers building the plant.

Electricians both install and maintain work on the energy systems of geothermal plants. When constructing plants, electricians check the 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.

Employment and wages. BLS does not currently have occupational wage or employment data specific to the geothermal industry. However, BLS does have data for the electric power generation, transmission, and distribution industry, which includes the operation of geothermal plants. Table 4 shows May 2011 BLS employment and wage data for the construction occupations in this industry group.

Preparation. Construction managers typically have completed an associate's degree or higher in construction management, business management, or engineering. They also usually have experience working on construction projects. Because experience is so important for construction managers, it may be substituted in some cases for educational requirements. But large, complex projects such as building a geothermal plant require specialized education. Workers who have a degree

Table 4: Employment and wages in selected construction occupations in the electric power generation, transmission, and distribution industry, May 2011

Occupations	Employment	Median annual wages
Carpenters*	578,910	$58,000
Operating engineers and other construction equipment operators	2,120	57,630
Construction laborers	1,030	43,480
Construction managers	490	95,630
Electricians	7,120	60,310
Plumbers, pipefitters, and steamfitters	1,130	68,800

* Industry-specific data are not available for this occupation. These data represent employment and wages for the occupation as a whole.

Source: U.S. Bureau of Labor Statistics, Occupational Employment Statistics.

in construction management or engineering but do not have significant experience may be hired as assistants to project managers.

Most construction laborers are trained on the job. Laborers typically work under the direction of a foreman. As they gain more experience and improve 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 have a combination of both. Certain equipment requires that operators 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 systems with which they work.

Plant operators

A completed geothermal plant needs staff to operate and monitor it. Power plant operators prevent or resolve any problems that would stop the plant from operating correctly.

Working in control rooms, power plant operators monitor power generation and distribution at a geothermal plant. They oversee the geothermal plant's pipes, generators, and instruments that regulate voltage and

electricity flows. They also communicate with electrical distribution centers on the regional power grid to match production with system load.

Power plant operators 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. They use computers to report unusual incidents, malfunctioning equipment, or maintenance performed during their shifts.

Employment and wages. BLS does not currently have occupational wage or employment data specific to the geothermal industry. However, BLS does have data for the electric power generation, transmission, and distribution industry group, which includes the operation of geothermal plants. In May 2011, BLS data show, there were 29,730 wage and salary power plant operators in this industry group, and they earned a median annual wage of $66,340.

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

For more information

To learn more about many of the occupations in this article, as well as hundreds of others, refer to the *Occupational Outlook Handbook* (*OOH*). The *OOH* is available online at **www.bls.gov/ooh**.

For more information about green careers, visit the BLS Green Jobs webpage at **www.bls.gov/green/greencareers.htm**. This article was adapted from a recent BLS report on the geothermal energy industry. To read that report, visit **www.bls.gov/green/geothermal_energy/geothermal_energy.htm**.

For information about careers working with geothermal power, visit your local One Stop Career Center. You can find a nearby career center online at **www.servicelocator.org**.

For more information about the geothermal energy industry, contact:

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For more information about geothermal and other types of renewable energy, visit the U.S. Department of Energy's Energy Efficiency and Renewable Energy Program online at **www.eere.energy.gov** or the National Renewable Energy Laboratory online at **www.nrel.gov**.