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AMERICA'S ALTERNATIVE ENERGY SOURCES

Geothermal

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Part One

At the earth's core, 4000 miles from the planet's surface, temperatures can reach over 9000 degrees Fahrenheit. This incredible heat originated four billion years ago in a fiery combustion of dust and gas, and scientists theorize radioactive decay keeps the heat generating and flowing outward from the core to the mantle of rock surrounding the core. When the temperature and pressure is high enough, some of this mantle rock melts. Then, because the melted rock or magma is less dense than the surrounding rock, it rises and moves slowly up to the earth's crust. Sometimes the hot magma reaches all the way to the surface as a volcanic eruption, but usually the magma remains below the Earth's crust and heats the adjoining rock as well as well as any water that has seeped deep into the earth. Some of this water, whose temperatures can reach as high as 700 degrees, travels through cracks to the earth's surface and emerges as hot springs, geysers, pools of boiling mud, and fumaroles. Far more often, however, the water and magma stays underground, trapped between cracks and rock in a natural geothermal reservoir.

This geothermal reservoir gives us another alternative energy with incredible potential. According to scientists, the thermal energy in the uppermost six miles of the Earth's crust contains 50,000 times the energy of all the oil and gas in the world.

For several thousand years, people have been using the geothermal waters that escaped to the surface for bathing, heating, cooking, and aquaculture. But credit for being the first to harness the power of geothermal energy goes to Francesco Larderel of Larderello, Italy. Larderel ran a company extracting boric acid from the hot springs that bubble up in this part of Tuscany. In 1827, faced with a dwindling wood supply to fire his boilers, Larderel developed a way to use the heat from the steamy waters for its own evaporation. Others followed his lead, and people

living in places as distant as Idaho and Iceland began using geothermal water, too. Then, in 1904 in Larderello, Prince Piero Ginori Conti successfully proved the region's geothermal steam could also generate electricity. Today, more than a century later, the geothermal steam of Larderello is still generating electricity for the Italian power grid.

Who is using it, and where?

Geothermal power plants produce electricity in geologically active locations all over the world. While the Earth's shifting plates and fault lines makes these "active" areas prone to earthquakes and volcanoes, these locations offer access to geothermal reservoirs at shallow enough depths and high enough temperatures, at least 225 degrees, to produce electricity economically. Such unique spots exist in the western U.S. plus Alaska and Hawaii, New Zealand, Iceland, Japan, Turkey, Mexico, India, Russia, and the Philippines and Indonesia. The Pacific Ocean's Ring of Fire, where most of the world's volcanic activity occurs, is a prime location for finding accessible geothermal reservoirs.

In the U.S., nearly 50 geothermal power plants are located in Alaska, Arizona, California, Hawaii, Idaho, New Mexico, Nevada, Oregon and Utah. In addition, the U.S. Geological Survey has identified other locations, where geothermal energy hides in reservoirs sufficiently hot enough and close enough to the surface to generate electricity. According to the Geothermal Energy Association, the industry trade group for this \$2-billion industry, another 50 geothermal projects are under development for these states. The world's largest geothermal site, California's Geysers Geothermal power plant located about 70 miles north of San Francisco, has been producing electricity for northern California since 1960.

But geothermal energy does not only generate electricity. Geothermal water, without need for pumps or power plants, heats everything from fish hatcheries to sidewalks. In the western U.S., according to the Geo-Heat Center, 271 communities or about 40,000 homes use geothermal resources for heating including Klamath Falls, Oregon, where geothermal water piped under roads and sidewalks keeps them from icing in winter. Rows of pipes carry geothermal water under the garden soil in New Mexico for a longer growing season and faster growth. Outside the U.S., geothermal district heating systems serve homes in Russia, China, France, Sweden, Hungary, Romania, Japan, and Iceland, where the world's largest district heating system heats the capital city. Since Reykjavik started using geothermal energy as its main source of heat, this once very polluted city has become one of the cleanest. But, just like the geothermal power plant, geothermal water can only be used directly in locations where the geothermal reservoirs are close to the surface.

Fortunately, the upper ten feet of Earth's surface maintains a constant temperature range between 50 and 60°F nearly everywhere in the world. This means even those of us who live far from an accessible geothermal reservoir can access geothermal energy by using a geothermal exchange heat pump, also known as a ground source heat pump.

How does all this work?

Geothermal exchange heat pumps capitalize on the constant temperature of the Earth's upper crust by transferring heat from the soil to the building in the winter and from the building to the soil in the summer. These pumps use the Earth itself as a heat source in the winter and as a heat sink in the summer. Through a system of underground or underwater pipes, the pumps transfer heat from the warmer earth to the building in the winter, and take the heat from the building in the summer and discharge it into the cooler ground. These pumps do not create heat, but they move the heat from one area to another.

Geothermal power plants work much like steam-powered plants and come in three basic types. Dry Steam plants use the steam as it comes from wells in the ground and direct it into the turbine/generator unit to produce power. Flash Steam plants, the most common, pump very hot water to the surface, where the pressure is suddenly dropped, allowing some of the hot water to "flash" into steam. The third type, the Binary Cycle plant, is the only able to produce electricity from cooler geothermal waters, roughly between 225 and 360 degrees. Because the world has more lower-temperature geothermal waters than high-temperature waters, scientists expect these binary cycle systems to become the dominant geothermal power plants of the future. The binary cycle plant gets around the need for steaming hot water by using a "working fluid," usually an organic compound with a low boiling point. In such a system, the hot geothermal water vaporizes the working fluid, and the steam from the working fluid drives the turbine. The geothermal water and the working fluid are confined to separate closed loops, so there are no emissions into the air

But all three types begin the same way: engineers locate a place where the Earth's crust has trapped steam and hot water in a shallow geothermal reservoir. Then a crew drills a deep well into the reservoir so the steam and hot water rises to the surface. Then the steam and water or a "working fluid" enters the power plant and turns a turbine to generate electricity. Finally, the water is returned to the ground to recharge the reservoir and complete the energy cycle.

How much geothermal energy is being used today?

According to the Geothermal Education Office in Tiburon, CA, 250 geothermal energy plants produce about 8000 megawatts of electricity worldwide running day and night in 22 countries. These plants provide reliable base-load power for well over 60 million people, mostly in developing countries, and world capacity is growing at approximately 9% per year.

The U.S., the world's largest producer of geothermal energy, produces about 2850 megawatts of electricity. American plants generate about 2% of the electricity in Utah, 6% of the electricity in California, almost 10% of the electricity in northern Nevada, and about 20% of the electricity for Hawaii's big island. Spurred by the rising cost of fossil fuels, new geothermal energy projects are underway in Alaska, Arizona, California, Hawaii, Idaho, New Mexico, Nevada, Oregon and Utah. These could provide, according to the Geothermal Energy Association, more than 2000 megawatts of new electric power for the grid, more than enough to power cities the size of Albuquerque, Las Vegas, Sacramento and Seattle combined. "This represents the U.S. geothermal industry's most dramatic wave of expansion since the 1980s," notes Karl Gawell, Executive Director of the Geothermal Energy Association. If completed, these new geothermal

projects will nearly double the installed geothermal power capacity in the U.S. to over 5000 megawatts and serve the needs of 1.8 million households.

In addition to the electricity produced by American geothermal power plants, 620 megawatts of thermal energy is used in the U.S. for direct-use applications such as indoor heating, greenhouses, food drying, and aquaculture. But by far the most widely used application of geothermal energy is the geothermal heat pump, generating over 7300 megawatts of thermal energy for the U.S.

In the summer, these pumps use the Earth as a cooling tower and, in the winter, as a heat sink. In Pennsylvania, the most common and perhaps only form of geothermal energy comes from these shallow well heat pumps. According to the Geothermal Heat Pump Consortium, more than one million geothermal pumps operate in the U.S. today, with the number of installations growing about 20 percent per year. Also, according to the Geothermal Heat Pump Consortium, the owners of these buildings enjoy lower utility bills (25% to 70% lower than with conventional systems); lower maintenance costs; and greater comfort. In addition, a geothermal exchange pump generates far fewer greenhouse gas emissions than a conventional furnace and eliminates any chance of carbon monoxide poisoning.

D. Costs?

Infrastructure:

Geothermal power projects require a lot initial capital for finding those shallow wells of geothermal reservoirs, for drilling down to these wells, and for building the plant. Once built, geothermal plants have low operating costs. According to the U.S. Department of Energy's Geothermal Technologies Program, the initial cost for the field and power plant is around \$2500 per installed kilowatt in the U.S. Operating and maintenance costs range from \$0.05 to \$0.08 per kilowatt hour. Reliable and efficient, geothermal power plants are available to generate power 95% of the time and are seldom off-line for maintenance or repair. And, they have the highest capacity factors of all types of power plants. Capacity factor is the ratio of the amount of electricity a plant produces to how much electricity it is capable of producing.

The cost to install a geothermal exchange heat pump varies but manufacturers tell residential customers to expect to pay between \$4,000 and \$11,000 more for a 3-ton GHP system than for an air source heat pump system. But the homeowner can then expect to save substantially, at least 25 percent, on heating and cooling costs.

Per Kilowatt Hour?

Electricity from geothermal power plants is economical, costing between .05 and .08 cents per kilowatt hour.

Part Two: Outlook for Geothermal Power

A. Pros and Cons

When properly developed and managed, geothermal systems provide a clean and safe source of energy requiring little land, lowering our dependence on fossil fuels and foreign imports, and providing reliable power 24 hours a day. In addition, a fossil fuel doesn't have to be stored or transported. As long as the water is returned to the geothermal reservoir and the high temperature maintained, the thermal energy of the reservoir can be very long lasting. The Lardarello field in Italy has been producing electricity since 1913, the Wairakei field in New Zealand since 1958, and The Geysers in California since 1960.

Through drilling a well through the Earth's crust to reach the reservoir is noisy and expensive, the operation of a geothermal plant is quiet and economical. Geothermal energy has a minimal impact on the landscape as a plant requires only a few acres and looks like a small light-industry building complex. After the location and installation, these plants are efficient, clean, and low in cost. Geothermal power stations typically achieve load factors of 90 to 95%, compared to typical load factors of 30 - 50% for other power plants, and they emit far less carbon dioxide than natural-gas-fueled power plant and produce little, if any, nitrous oxide or sulfur-bearing gases. Binary plants are closed cycle operations, so they release no emissions. Because geothermal power plants do not burn fossil fuels, they offset the air pollution that would have been produced by a more conventional power plant. In addition, the energy is freely available as long as water is returned to the reservoir and the hot temperature of the water is maintained.

On the con side, geothermal power is site specific. Unless the technology changes, we cannot expect to generate electricity from a geothermal power plant in Pennsylvania, although we can capitalize on the Earth's relatively constant temperature with the installation of geothermal heat exchange pumps in our buildings. The hope for the future seems to lie in the development of technology to tap the energy that exists in the hot dry rock that is several miles beneath the Earth everywhere, and work is underway to figure out the best ways to drill into this rock, inject cold water down one well, circulate it through the hot rock, and draw the now heated water from another well. One day we might also be able to recover heat directly from the magma. In these ways, we can generate electricity without the presence of a shallow geothermal reservoir of steam and water.

Meanwhile, some question whether geothermal power is as renewable as has been claimed. Energy production at geothermal power plants can gradually decline over time through loss of water and steam and gradually lowering temperatures. Water must be returned to the reservoir to maintain pressure and production, so the City of Santa Rosa, Calif. now pipes its treated wastewater to The Geysers reservoir fields, prolonging the life of the reservoir and recycling the treated wastewater. It seems sustainable energy is possible, if the water is returned to the reservoir and the temperature in the reservoir remains high. Other negative includes the sinking of the ground where the water and steam is removed from an underground reservoir and the chance a power plant could trigger an earthquake in seismically active areas.

B. Barriers?

Several factors inhibit the growth of geothermal power plants. These plants can only be located at place with accessible reservoirs of suitable type and temperature. Often these geothermal sites are located in protected wilderness areas that environmentalists do not want disturbed. Even "limitless" geothermal reservoirs can "run out of steam" when more steam and hot water is

withdrawn than is recharged or injected. So, “inexhaustible” reservoirs can run out. Hazardous gases and minerals may come up from underground, posing a disposal problem. Because of these negative factors, investors sometimes shy from geothermal. New geothermal power plants have been eligible for a Production Tax Credit for the first five years of operation, up to Dec. 31, 2007. But the Geothermal Energy Association believes geothermal power faces big challenges this year, as the budget proposes to eliminate some of the provisions of the Energy Policy Act that helped geothermal research. Instead of providing the resources needed for the Bureau of Land Management to work off its 25-year backlog of lease applications, for example, the budget proposes to repeal this and other provisions.

C. Incentives?

According to Karl Gawell, executive director of the Geothermal Energy Association, the most significant catalyst behind the recent flurry of new geothermal plants was the passage of the Energy Policy Act by Congress in 2005. This made new geothermal plants eligible for the full federal production tax credit, previously available only to wind projects. It also authorized and directed increased funding for research by the Department of Energy and gave the Bureau of Land Management new legal guidance and deal with the backlog of geothermal leases and permits. “If we can build and sustain the momentum that EPAct has given the industry,” says Gawell, “geothermal energy can become a major U.S. energy source.”

Part 3: Recommendations

Geothermal energy is an enormous, underused heat and power resource that is clean, reliable, and homegrown. The current production of geothermal energy from all uses places it third among renewable energies, following hydroelectricity and biomass, and ahead of solar and wind. Despite these impressive statistics, its use pales in comparison to the immense amount of geothermal energy. The key to its wider user seems two-fold. First, public awareness of the savings possible through the use of a geothermal pump: if more people knew about the advantages gained from heating and cooling with geothermal heat exchange pumps, they would install them. Secondly, technological breakthroughs are needed to uncover ways to produce electricity from “cooler” geothermal waters, from hot dry rock, and from magma.

The potential is enormous and it is waiting there, just below our feet.

Sources

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Geothermal Heat Pump Consortium
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