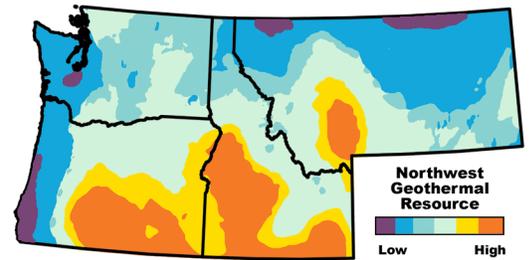


# Geothermal Power



Renewable Northwest Project



GEOTHERMAL ENERGY IN THE NORTHWEST	
Total potential supply	>2,600 aMW
Resource type	baseload
Capacity factor	≥ 90%
Construction lead time	1–3 years
Real levelized cost (2006\$)	4.5–7.5¢/kWh
Operating life	30–50 years
U.S. geothermal developed	2,544 MW*
NW proposed	263 MW

\*Installed capacity as of Dec 2004.

MW= Megawatts (capacity),

aMW = average MW;

Sources: see endnote 1

## WHAT IS GEOTHERMAL POWER?

Geothermal energy is heat from deep in the earth. The heat is brought near the surface by underground circulation of water and by the intrusion into the earth's crust of molten magma. The portion of geothermal energy that can be developed easily is trapped in cavities beneath the earth's surface. A geothermal plant pumps the steam or hot water from these cavities to the surface, uses it to run an electrical generator, then returns the fluids to the underground cavities.

## POTENTIAL

The Northwest has the potential to generate more than 2,600 average megawatts of electricity from geothermal power, or enough clean, renewable energy to meet the annual needs of almost 2 million average homes. Although estimates of available resources are uncertain until exploratory work is done, the Northwest

Power Planning Council has identified eleven specific areas where it expects there are about 2,000 megawatts of developable geothermal resources.

Geothermal areas in the western United States are usually found where there has been relatively recent volcanic activity. Virtually all of the geothermal electric generation developed in the U.S. so far has been in California and Nevada. The most promising sites in the Northwest are in the Basin and Range area of southeastern Oregon and southern Idaho, as well as some areas along the Cascades in Oregon, Washington and northern California.

Significant potential also exists in the Northwest for direct, non-electric use of geothermal heat. Low-temperature geothermal district heating has been used for decades in Klamath Falls, Oregon, and Boise, Idaho.<sup>2</sup>

## COST

Real levelized costs for geothermal electricity generation are 4.5–7.5 cents per kilowatt-hour – competitive with many fossil fuel facilities, but without the pollution. Delivered costs depend on ownership arrangements, financing, transmission, the quality of the resource, and the size of the project. Geothermal plants are built of modular parts, with most projects including one or more 10–50 MW turbines.

Geothermal plants are relatively capital-intensive, with low variable costs and no fuel costs. Usually financing is structured so that the project pays back its capital costs in the first 15–20 years, delivering power at 5–7¢/kWh. Then costs fall by around 50 percent, to cover just operations

***“The Northwest has the potential to generate enough geothermal energy to meet the needs of almost 2 million average homes.”***

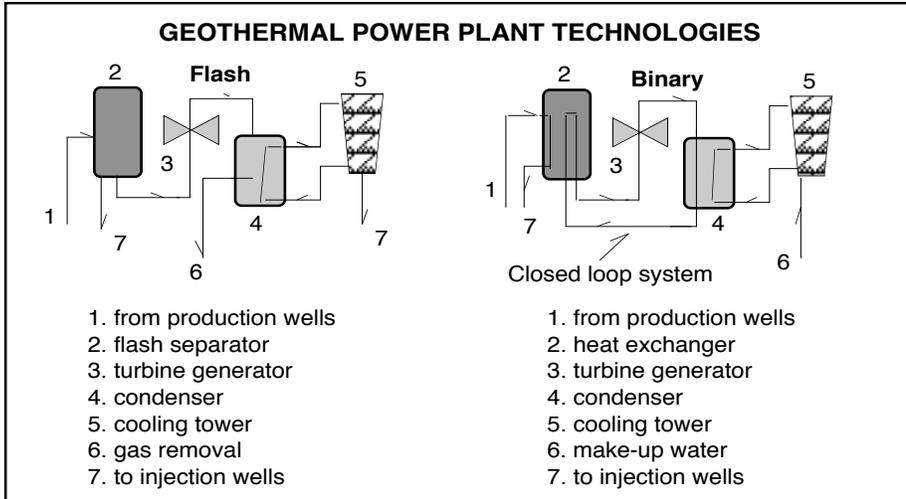
and maintenance for the remaining 10–20 years that the facility operates.<sup>3</sup>

## ECONOMIC BENEFITS

Geothermal power, like all renewable resources, keeps economic benefits local. The most promising geothermal project sites are in rural areas. Geothermal power provides local jobs, retains dollars locally, pays local property taxes, and contributes royalties to the local county to support services. A study by the Oregon Department of Energy found that a 100 MW project in Eastern Oregon could create over a million dollars of additional local income each year, and would pay \$4–6 million in local and state fees, royalties and taxes. In contrast, a similarly sized natural gas project sends \$20–35 million out of the region every year for fuel costs alone.<sup>4</sup>

## HOW IT WORKS

There are several types of geothermal power technologies. Most of the installed geothermal electrical generating plants use either flash or binary technologies. Generally, flash technologies are used when the geothermal resource has temperatures of 350°F and higher, and binary technologies are used with temperatures below 350°F. In both technologies, the geothermal fluids are returned to the underground reservoirs and naturally reheated for reuse.<sup>5</sup>



In a **flash** steam process, (see diagram) water from underground wells is separated (flashed) into steam and water. The water is directly returned to the geothermal reservoir by injection wells, or cycled for other process or agricultural uses before re-injection. The steam is used to drive a turbine and generate electricity. Any gases in the steam are removed and, if necessary, treated to remove dissolved pollutants. The steam is cooled to liquid form and then also re-injected into the geothermal reservoir. For very high temperature resources, the water can be controlled to flash more than once to recover even more energy from the same resource.

A **binary** power plant is used for moderate-temperature resources. The hot water from a geothermal source is used to heat a secondary working fluid, such as ammonia or isobutane, in a closed-loop system. The working fluid is vaporized in a heat exchanger and is then used to drive a turbine-generator. A cooling system is used to condense the vaporized working fluid back into liquid form to begin the process again. The hot water from the geothermal resource is injected back into the reservoir. The hot water and the working fluid are kept separate, so that environmental issues are minimal.

## SYSTEM INTEGRATION

Geothermal plants are one of the most reliable of all electricity sources, regularly operating at 90 percent or more of their rated capacity year-round. Because they can run continuously, geothermal plants are most often used for providing baseload energy. In addition, some plants in Italy and at The Geysers in California have been used to help meet daily peak loads. Geothermal power can provide significant system diversity, stability and transmission benefits, thereby increasing system reliability and lowering overall operating costs.<sup>6</sup>

## ENVIRONMENTAL IMPACTS

Although geothermal is one of the more benign power sources, it must be properly sited to prevent possible environmental impacts. New geothermal systems re-inject water into the earth after its heat is used, in order to preserve the resource and to contain gases and heavy metals sometimes found in geothermal fluids. Care must be taken in planning geothermal projects to ensure that they don't cool nearby hot springs or cause intermixing with ground water. Geothermal projects can produce some carbon dioxide emissions, but these are up to 35 times lower than the cleanest fossil-fuel power plants of the same size.<sup>7</sup>

## MORE INFORMATION

National Renewable Energy Laboratory: [www.nrel.gov/](http://www.nrel.gov/)

Geothermal Resources Council: [www.geothermal.org/](http://www.geothermal.org/)

Geothermal Energy Association: [www.geo-energy.org/](http://www.geo-energy.org/)

### Sources and Notes:

<sup>1</sup> Resource potential from *Renewable Energy Atlas of the West*, Land and Water Fund of the Rockies, et al. (July 2002).

- Levelized costs from "Power Plant Costs", Geothermal Energy Association (GEA) (Aug 2005), <http://www.geo-energy.org/aboutGE/powerPlantCost.asp>, accessed 9/25/06.

-U.S. installed capacity from International Geothermal Association (IGA), (Aug 2006), <http://iga.igg.cnr.it/geoworld/geoworld.php?sub=elgen&country=usa>, accessed 9/25/06.

-Proposed projects from "Renewable Energy Projects Serving Northwest Load", Renewable Northwest Project, (Sept 2006), <http://www.rnp.org/Projects/projectlist.php>, accessed 9/25/06.

<sup>2</sup> Resource potential from Land and Water Fund of the Rockies, et al., *op. cit.* note 1; and *Fourth Northwest Conservation and Electric Power Plan*, Northwest Power Planning Council (NWPPC), 1998. Assumes average home consumes 12,000 kilowatt-hours per year.

-Existing U.S. development from IGA, *op. cit.* note 1.

<sup>3</sup> Cost info from GEA, *op. cit.* note 1.

<sup>4</sup> *Economic Impacts of Geothermal Development in Deschutes County, Oregon*, Oregon Dept. of Energy (1991).

- Natural gas fuel cost assumes a 55% efficient combined cycle plant with a 90% capacity factor using natural gas at \$4-\$7/mmBtu.

<sup>5</sup> This section and diagram based on NWPPC, *op. cit.* note 2, and *Investing in the Future: A Regulator's Guide to Renewables*, National Association of Regulatory Utility Commissioners (1993).

<sup>6</sup> *Renewable Energy Technology Characterizations*, Electric Power Research Institute/U.S. Dept. of Energy, 1997, ch. 3.

<sup>7</sup> "What is Geothermal Energy", IGA (Feb 2004), <http://iga.igg.cnr.it/geo/geoenergy.php>, accessed 9/25/06.