National GEOTHERMAL Collaborative

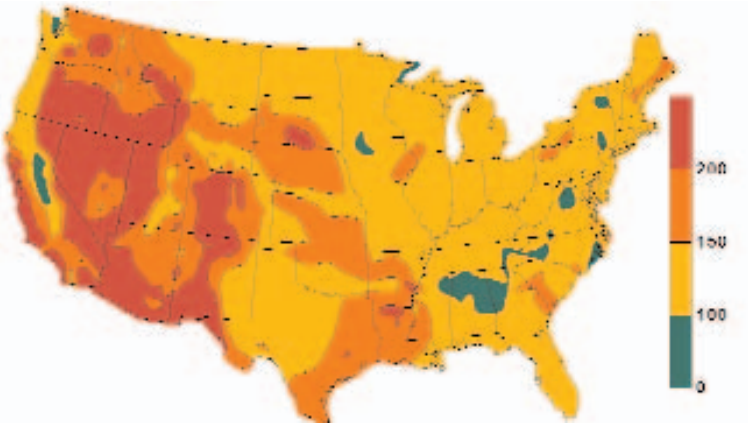
Location of Geothermal Resources

Geothermal resources, which utilize the heat of the earth, are located throughout the planet's crust. Those closer to the surface are most commonly used because geothermal drilling costs are currently prohibitive below depths of between 10,000 and 15,000 feet. The hottest domestic geothermal resources are most easily accessible in the western United States, but low temperature resources that are practical for direct use applications are more widespread.

■ Geothermal Resource Potential

The earth generates a tremendous amount of heat energy. Figure 1 shows the expected heat in the earth at a depth of six kilometers (19,685 feet). Oil and gas drilling technology has allowed successful drilling to even greater depths. The drilling depth record of 33,200 feet was established in the Gulf of Mexico in January, 2004. Currently, geothermal drilling technology is best suited to tap resources that are located at an intersection of underground heat, water and fractured rock. Figure 1 shows only estimates of underground heat, but not the places where high heat co-exists with fractured rock and water. Advancements in Enhanced Geothermal Systems technology are expected to tap geothermal resources in areas where these ideal heat, water and rock conditions do not exist, and to economically recover resources at much greater depths.

Figure 1: Estimated Earth Temperatures at 6 km Depth (3.6 miles)



Note:
A significant number of the geothermal areas lack sufficient water and/or permeability to enable the affordable production of geothermal energy. Presently, only high-grade (i.e. shallow, hot, and permeable) hydrothermal reservoirs generate electricity economically.

Source: Geothermal Laboratory, Southern Methodist University, 2003.
http://www.eere.energy.gov/geothermal/geomap.html

■ Technology and Resources

Figure 1 gives a general idea of where geothermal resources may exist but much more exploration and drilling is needed to determine precisely where the best resources are located. Geothermal power plants and direct-use projects must be built near the geothermal resource because it is not generally practical to transport steam or hot water over great distances. Heat pumps are useful anywhere in the country because they do not rely on reservoirs of steam or hot water. (Figure 2 indicates where various geothermal technologies are used across the United States.) Since geothermal production occurs near the location of the resource, it costs very little to obtain and transport fuel to the power plant, especially compared to many traditional power plants. Many fossil fuel power plants can be built over a wider range of areas but require constant fuel purchases and shipments over their lifetime.

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Power Generation

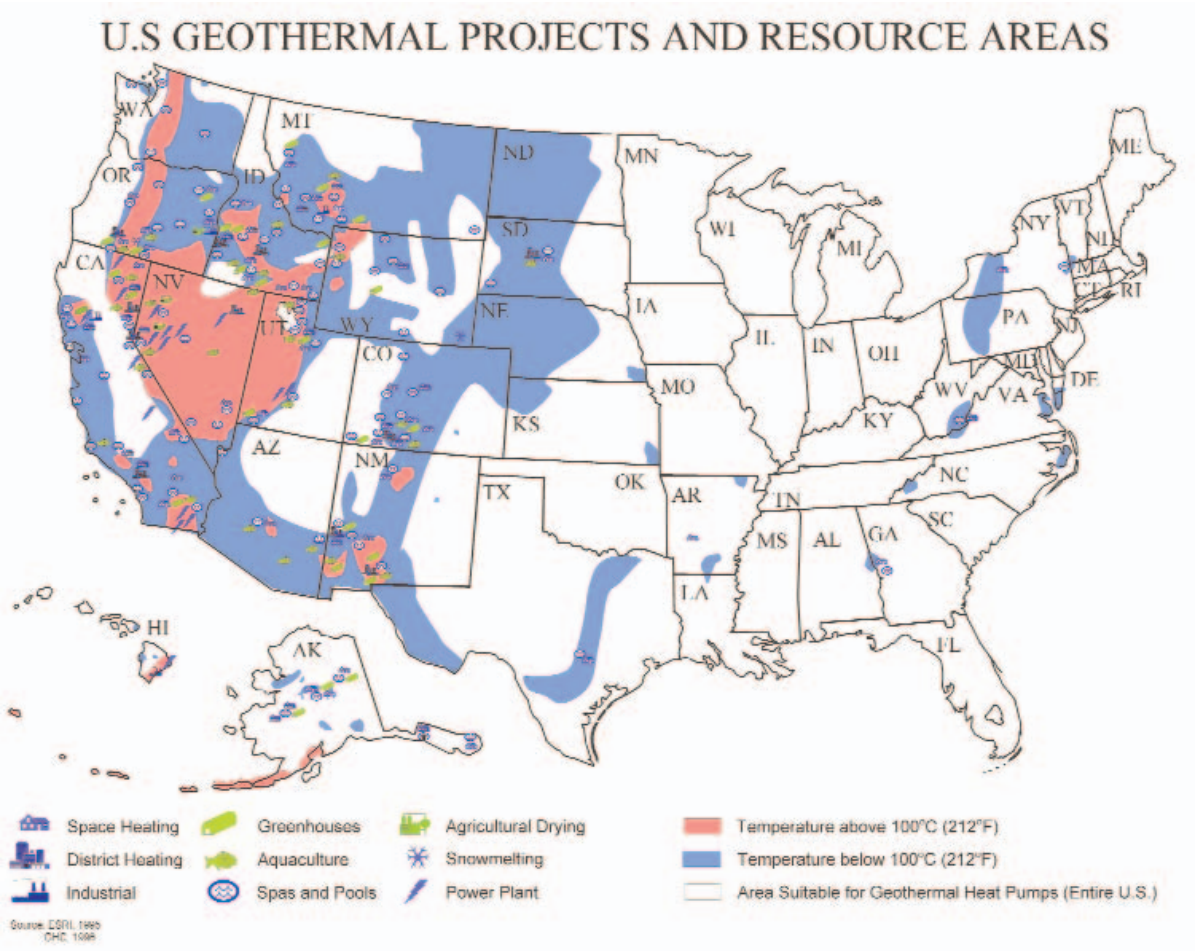
The white and dark gray areas of Figure 1 indicate regions with the highest potential for generating electricity. Geothermal power plants generally use resources with temperatures greater than 250°F to generate power economically, although advanced systems can use resources as low as 190°F. Electricity is currently being produced economically in California, Hawaii, Nevada and Utah. Improvements in public policy and advances in technology are expected to expand the use of geothermal power.

Direct Use

Direct-use projects are practical throughout a larger area of the country because they use more widespread, low-temperature resources (generally between 70°F and 300°F) to heat and cool buildings, provide heat to dry food and lumber and support fish farming and greenhouses. Although the high-potential regions for resources within this range include all areas of Figure 1 except those in black, the economic limitations of drilling to the depth indicated limit direct use development potential to those area in dark grey and white. (For more detailed information, see "Geothermal Direct-Use" at www.geocollaborative.org/publications.)

Geothermal Heat Pumps

Geothermal heat pumps are practical across the country because they do not rely on the reservoirs of geothermal steam or hot water that are found only in certain states. Instead, heat pumps use the constant temperature of the earth at a much shallower depth to transfer heat to a building in the winter, and from a building to the earth to cool it in the summer. More than one million geothermal heat pumps (with a total capacity to generate approximately 8,600 MW of heat) are in operation across the country and their numbers are growing more than 20 percent a year. Geothermal power plants represent large capital investments in the counties in which they are constructed. The property taxes that the power plants generate can be significant, especially since many are located in more rural areas with an otherwise declining property tax base.

Figure 2: Geothermal Uses in the United States (shown below)

Note: See http://geoheat.oit.edu/dusys.htm for an interactive version of this map.