The United States Department of Energy invests in the development of hydrothermal resources to generate geothermal energy. These resources can be broken into four categories:

Conventional Resources

Conventional hydrothermal resources naturally contain the permeability, fluid, and heat (over 150°C) needed to generate electricity. This constitutes the majority of current global geothermal resource developments.

Low-Temperature Resources

Low-temperature resources are hydrothermal resources with temperatures below 150°C. There are numerous applications for low-temperature geothermal energy, including power generation, direct space heating, aquaculture, agriculture, and drying. Increasingly, low-temperature resources can now be used for power generation under the right conditions.

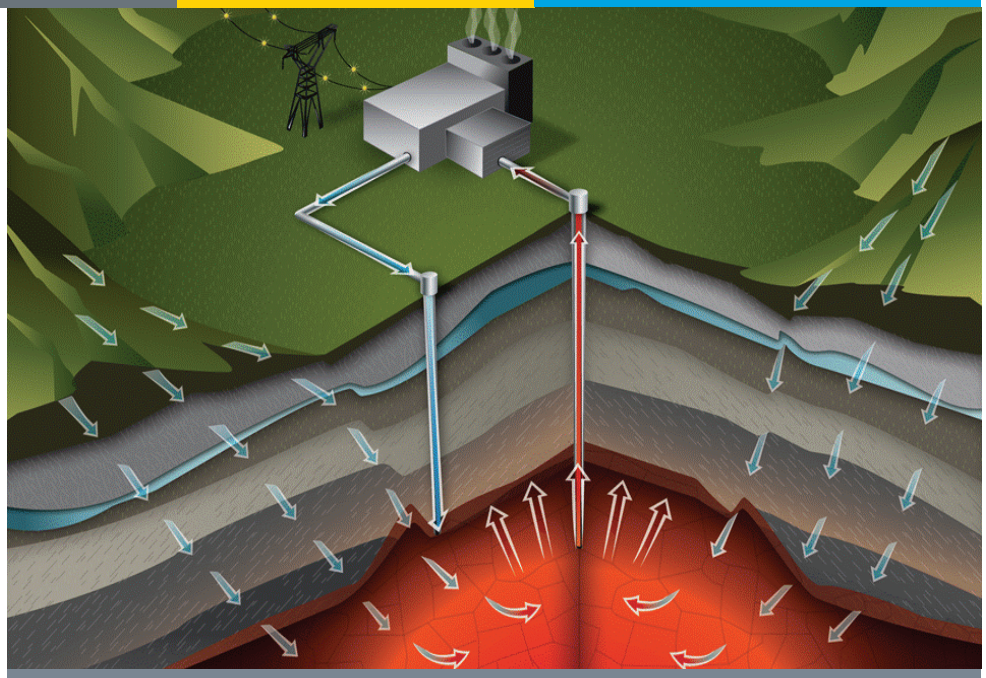
Co-produced Resources

Co-produced resources use hot fluid that is a by-product of oil, gas, and other hydrocarbon production to generate electricity, with potential to significantly offset greenhouse gas emissions and extend the economic life of oil and gas fields. The quality of the resource depends on the water volume and temperature.

Geopressured Resources

In some cases, geofluids are trapped under an impermeable layer of caprock while a layer of sediment rapidly builds over it. The resultant high-pressure environment can have temperatures which range from 90°C to over 200°C. These reservoirs may also contain dissolved natural gas that may be practical to develop in combination with geothermal energy production.

Visit the Geothermal Technologies Office website at geothermal.energy.gov for more information on hydrothermal development, or contact geothermal@ee.doe.gov.



Geothermal energy, accessed through fluid in the hot rocks at a depth up to several miles, supplies a steady flow of high-pressure steam or water to create electricity.

Hydrothermal Resources

A geothermal resource requires fluid, heat, and permeability to generate electricity. Conventional hydrothermal resources contain all three components naturally. These geothermal systems can occur in widely diverse geologic settings, sometimes without clear surface manifestations of the underlying resource.

In 2008, the U.S. Geological Survey (USGS) estimated that 30 GWe of undiscovered geothermal resources exist in the western United States[1]—ten times the current installed capacity. Minimizing the risks and costs of discovering and characterizing these new geothermal energy sources is therefore vital to realizing geothermal as a significant contributor to the nation's baseload energy supply.

The Process

Developing a hydrothermal system begins with fully characterizing the resource. Once the subsurface is well understood and a geothermal prospect is identified, the reservoir is then accessed by drilling. After confirming sufficient resource, size, and extent, power plant development can begin.

[1]Williams, Colin F., Reed, Marshall J., Mariner, Robert H., DeAngelo, Jacob, Galanis, S. Peter, Jr. *Assessment of Moderate- and High-Temperature Geothermal Resources of the United States.* (U.S. Geological Survey Fact Sheet 2008-3082) http://pubs.usgs.gov/fs/2008/3082/.

[2]Young, Katherine R., Chad Augustine, and Arlene Anderson. *Report on the U.S. DOE Geothermal Technologies Program's 2009 Risk Analysis.* (NREL/ CP-6A2-47388: U.S. Department of Energy, 2010) http://www.nrel.gov/docs/fy10osti/47388.pdf.

Hydrothermal Reservoir Creation and Operation

Step 1: Characterization

Properly characterizing the subsurface in hydrothermal settings is costly. In fact, resource confirmation relies on drilling multi-million dollar wells so that improving the chance of success has an immediate bottom line impact. The Geothermal Technologies Office (GTO) invests in hydrothermal technology to:

1. Develop innovative methods to better characterize the subsurface.
2. More accurately identify potential geothermal resources.
3. Advance a higher drilling success rate, decrease risk, and lower costs.
4. Confirm 400 megawatts (MW) of new hydrothermal resources by 2014.
5. Help lower the levelized cost of hydrothermal energy to 6 cents per kWh by 2020.

Step 2: Access

Once a potential resource is identified through exhaustive resource characterization efforts, the focus shifts towards developing a detailed drilling plan where specific sites and methods are outlined. These plans often include drilling temperature gradient wells, slim and/or core holes, and, finally, production wells.

Well costs approach 50% of the total project cost for a geothermal power project. These costs can also be a significant barrier to widespread deployment of geothermal power production. The Department of Energy continues to invest in advanced drilling technologies focused on increased efficiency, decreased drilling times, and reduced overall well costs.

Step 3: Power Conversion

Successfully accessing and confirming the resource leads to commercial development of the site through power conversion technologies. The best way to utilize the resource is based on the temperatures, permeability, and fluid characteristics discovered during resource confirmation. The Department of Energy invests in targeted research and development to increase plant and operating efficiencies and lower costs of geothermal power production.

Exploration methods are categorized into five groups:

Geology
Characterizing geology—rock types, structures, faults, and temperatures—is a fundamental step in discovering new geothermal resources. This information comes from a diverse set of sources—geology, maps, existing wellbores, etc.—which is then combined using cross-sections and mechanical relationships to create an accurate representation of the subsurface.

Geophysics
Potential fields methods (e.g. gravity, magnetics, magnetotellurics), heat flow mapping, and advanced seismic techniques along with improvements in interpreting those data help identify and define hidden geothermal resources.

Remote Sensing
Geospatial data collected from air/space—LiDAR and InSAR, for example—are used to identify surface indicators of a geothermal resource for large or less accessible areas.

Geochemistry
Sub-soil gas, hydrocarbon, and isotope data, along with fluid samples from wells and springs, are used to identify possible up-flow areas and constrain sub-surface temperatures—a simple and cost-effective method to target resources with little or no surface expression.

Cross-cutting
The combination of methods listed above leverages and intertwines strengths from individual techniques for a more complex and complete characterization of the resource.

Beowawe Power Plant, a low-temperature, binary cycle plant, uses waste heat from an existing geothermal plant at the facility, which added 1.8MW to the existing plant's nameplate capacity of approximately 17.7 MW. The project was funded in part by the Geothermal Technologies Office under the American Recovery and Reinvestment Act. *Photo courtesy of Terra-Gen*

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Visit geothermal.energy.gov or email geothermal@ee.doe.gov.

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