



Geothermal Energy



The Earth's heat, which constantly flows outward from its core, provides an enormous source of energy called *geothermal energy*. The word geothermal comes from the Greek words *geo* (earth) and *therme* (heat). So, geothermal energy is heat from within the Earth.

Renewable Geothermal Energy

Geothermal energy is a renewable energy source because the heat is continuously produced inside the Earth. Most of the geothermal reservoirs in the United States are located in the western States and Hawaii. California generates the most electricity from geothermal energy. "The Geysers" dry steam reservoir in northern California is the largest known dry steam field in the world and has been producing electricity since 1960.

If you live in the western United States, you may have the opportunity now or in the future to buy clean electricity from a geothermal power plant. Also, if you happen to live in an area that has access to a geothermal reservoir of low-to-moderate temperature (68°F-302°F) water, you can tap into it for a direct use application. Direct use applications include home heating, greenhouse heating, district heating, and fish farming.

Twenty countries including the United States had geothermal power plants in 2008, which generated a total of about 60.4 billion kWh. The Philippines was the second largest geothermal power producer after the United States at 9.8 billion kWh, which equaled about 17% of the country's total power generation. Geothermal power plants in El Salvador and Iceland produced about 1.4 and 3.8 billion kWh respectively, which was equal to about 25% of the total power generated in those countries.

Use of Geothermal Energy

You may have also heard of using a geothermal or ground-source heat pump to heat and cool your home. This energy-saving technology uses the constant temperature just below the earth's surface to help keep your home warm in the winter and cool in the summer, saving you money while maintaining a comfortable temperature.

Some applications of geothermal energy use the Earth's temperatures near the surface, while others require drilling miles into the Earth. The three main uses of geothermal energy are:

- **Direct use and district heating systems** use hot water from springs or reservoirs near the surface.
- **Geothermal heat pumps** use stable ground or water temperatures near the Earth's surface to control building temperatures above ground.
- **Electricity generation power plants** require water or steam at very high temperature (300° to 700°F). Geothermal power plants are generally built where geothermal reservoirs are located within a mile or two of the surface.

Geothermal Power Plants

Geothermal power plants use **hydrothermal** resources that have two common ingredients: water (hydro) and heat (thermal). Geothermal plants require high temperature (300°F to 700°F) hydrothermal resources that may come from either dry steam wells or hot water wells. We can use these resources by drilling wells into the Earth and piping the steam or hot water to the surface. Geothermal wells are one to two miles deep.

Types of Geothermal Plants

There are three basic types of geothermal power plants:

- **Dry steam plants** use steam piped directly from a geothermal reservoir to turn the generator turbines. The first geothermal power plant was built in 1904 in Tuscany, Italy, where natural steam erupted from the Earth.
- **Flash steam plants** take high-pressure hot water from deep inside the Earth and convert it to steam to drive the generator turbines. When the steam cools, it condenses to water and is injected back into the ground to be used over and over again. Most geothermal power plants are flash steam plants.
- **Binary cycle power plants** transfer the heat from geothermal hot water to another liquid. The heat causes the second liquid to turn to steam which is used to drive a generator turbine.



GEOTHERMAL DEMONSTRATION ACTIVITIES

1. What factors affect the heat transfer from rock to water?

Learning Objective: The students will know and understand that heat flow is a function of the heat capacities of the substances involved in the transfer as well as the substances' starting temperatures.

Controls and Variables: type of rock, mass of rock and water, starting temperatures of rock and water, time

Safety and Environmental Requirements: Caution should be used when handling hot materials.

Suggestions:

Rock samples should be heated to a constant temperature, then placed into water of known temperature in the calorimeter or cup. From here, the students can measure the total energy change or the rate of energy transfer, compare rock samples or masses of the same rock, or even substitute different metals or household materials.

2. How is energy transferred between fluids in a binary geothermal power plant work?

Learning Objective: The students will know and understand that conduction can transfer thermal energy from one liquid to another.

Controls and Variables: container size, volume of liquid, temperature of liquid, type of liquid, time, material of transfer bar or nail

Safety and Environmental Requirements: Caution should be used when handling hot materials. Alcohol is volatile and should be kept away from any heat source.

Suggestions:

Students can select from the many different variables in this experiment. For example, they can determine the effects of large volumes of liquid on smaller volumes or vary starting temperatures of liquids.

They can also experiment with nails or transfer bars made from different metals and/or liquids with different boiling points.

Materials for Project 1:

- Styrofoam cups with lids OR calorimeters
- thermometers
- water at room temperature
- small samples of various types of rocks (i.e. granite, basalt, sandstone, gneiss),
- mass balance
- boiling water bath OR incubator to heat rocks
- tongs
- graduated cylinders

Materials for Project 2:

- Heat transfer kit OR Styrofoam cups w/ lids
- large nails (bent into U shape)
- thermometers
- water at various temperatures
- other liquids (alcohol)
- graduated cylinders

Credits:

*U.S. Department of
Energy's
Office of Energy Efficiency
and Renewable Energy,
US EPA, Energy Kids US
Energy Information
Administration*



GEOTHERMAL DEMONSTRATION ACTIVITIES

3. How does salinity affect the boiling point of water?

Learning Objective: The students will know and understand that the concentration of solutes in a solution will affect the boiling point of the liquid.

Controls and Variables: type of liquid, volume of liquid, amount of solute, type of salt, boiling point of solution

Safety and Environmental Requirements: As with all experiments that involve heating and pressure you will need to wear eye protection and heat insulating gloves.

Suggestions: Students can select from many different variables in this experiment. For example, they can determine how the same salt affects the boiling point of different liquids, or how different salts affect the boiling point of water.

4. How do the emissions from a geothermal power plant compare to those from a fossil fuel power plant?

Learning Objective: The students will know and understand that the combustion products from fossil fuel power plants contain particulates (soot) and contribute to air pollution, while the major emission from a geothermal power plant is clean water.

Controls and Variables: fuel source, time, mass of particulates, mass of fuel source

Safety and Environmental Requirements: Caution should be used when handling hot materials, especially the mirror. Fuels are combustible and should be kept contained while burning. When using the Bunsen burner, be sure to keep the mirror high above the flame.

Suggestions: Students can use multiple fuel sources to determine the amount of particulates produced by each source.

Materials for Project 3:

- hot plate
- beakers
- high range thermometers
- water or other liquids
- sodium chloride or other salt
- mass balance
- graduated cylinders

Materials for Project 4:

- combustible materials such as candles
- Sterno cans
- Bunsen burners
- charcoal
- wood chips
- matches
- small pie tins for burning materials
- hot plate
- teapot
- water
- small mirror
- tongs
- oven mitts
- 0.01 gram mass balance

Credits:

*U.S. Department of
Energy's
Office of Energy Efficiency
and Renewable Energy,
US EPA, Energy Kids US
Energy Information
Administration*