
Geothermal Energy

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Geothermal Energy – Overview

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- Geothermal Reservoirs
- Extracting Geothermal Energy and Uses
- Geothermal Plants – Dry Steam, Flash Steam, Binary Cycle
- Cost
- Geothermal Energy in World
- Advantages
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- Conclusion

Geothermal Basics

- Geothermal energy is the heat from the Earth. (*Geo* means “earth,” and *thermal* means “heat” in Greek.)
- It is a clean, renewable resource that provides energy in the United States and around the world.
- It is considered a renewable energy resource because the heat emanating from the interior of the Earth is essentially limitless.
- The heat continuously flowing from the Earth’s interior is estimated to be equivalent to 42 million megawatts of power. One megawatt is equivalent to 1 million watts, and can meet the power needs of about 1,000 homes.

Geothermal Basics

- The interior of the Earth is expected to remain extremely hot for billions of year to come, ensuring an essentially limitless flow of heat.
- Geothermal power plants capture this heat and convert it to energy in the form of electricity.
- The picture below shows the source of geothermal electric power production, heat from the Earth.
- As depth into the Earth's crust increases, temperature increases as well.

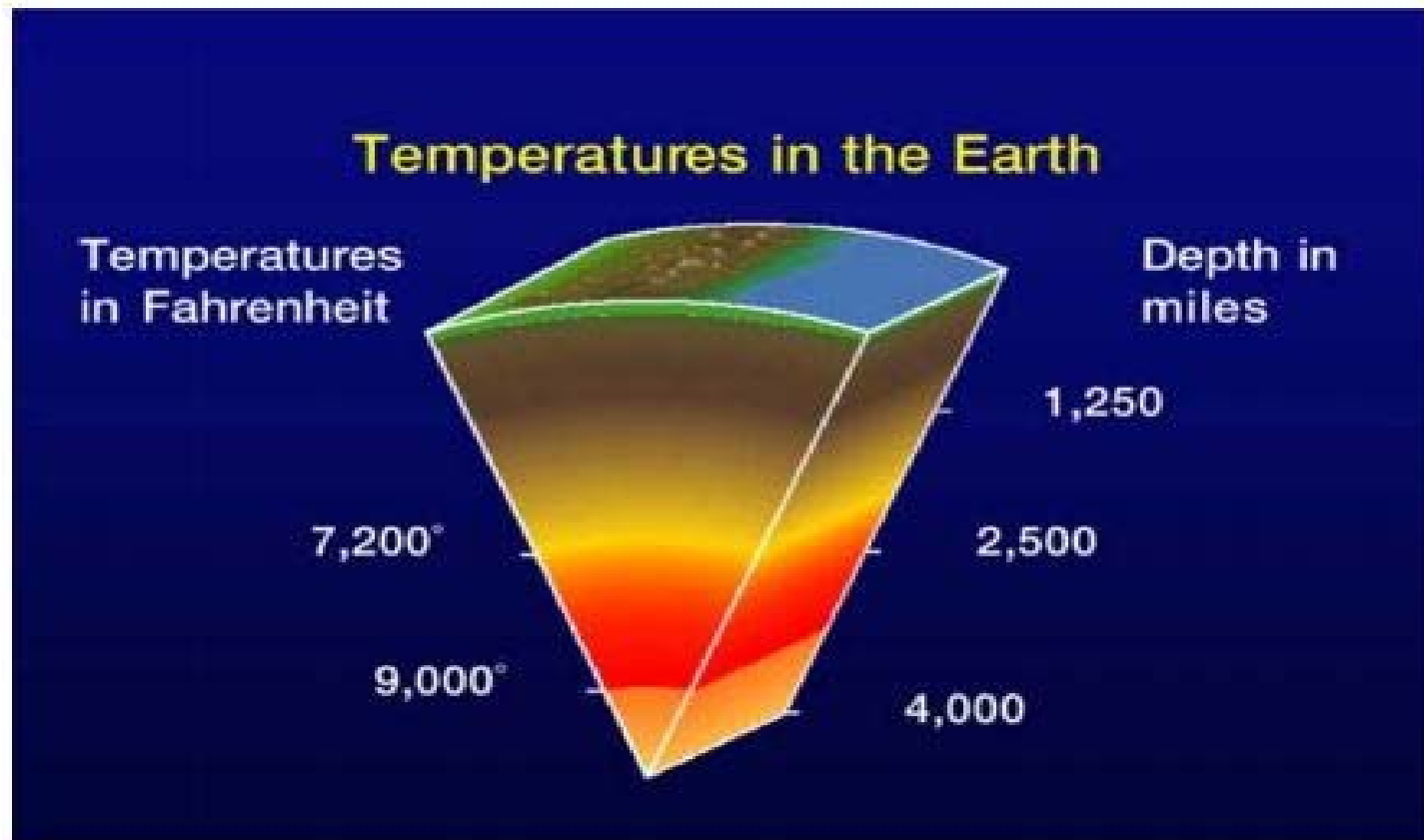
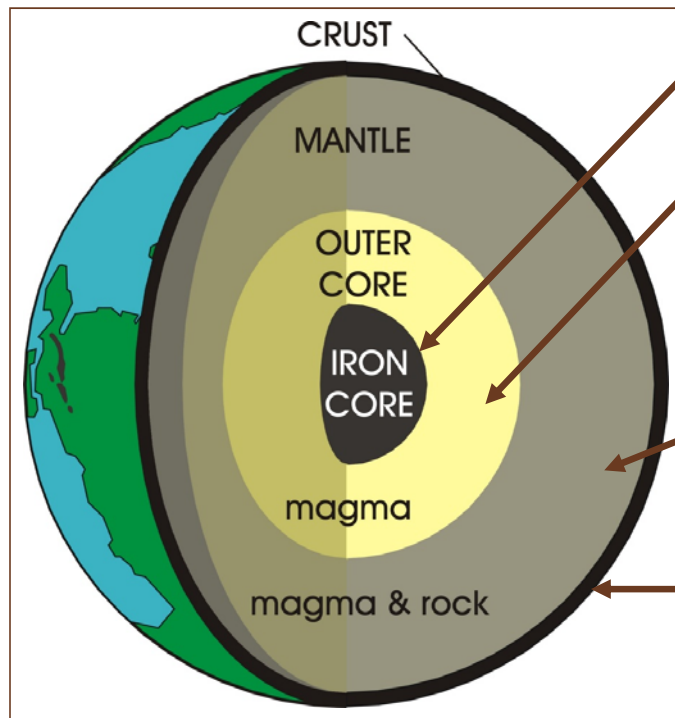


Figure 1. Earth's Temperature

Source: Geothermal Education Office

Earth's Different Layer



At the center is a **core** of iron.

Around that is an outer core of iron and rock so hot the rock is melted.

The liquid rock is called **magma**.

The next layer is a mixture of rock and magma called the **mantle**.

The shell of the earth – with the oceans and mountains - is called the **crust**.

Geothermal Reservoirs

- Heat emanating from the Earth's interior and crust generates magma (molten rock).
- Because magma is less dense than surrounding rock, it rises but generally does not reach the surface, heating the water contained in rock pores and fractures.
- Wells are drilled into this natural collection of hot water or steam, called a **geothermal reservoir**, in order to bring it to the surface and use it for electricity production.
- **Reservoir** can be suspected in the area where we find 1) Geyser 2) Volcano 3) Hot Springs.

1) Geysers

- A **geyser** is a type of hot spring that erupts periodically, ejecting a column of hot water and steam into the air.
- The formation of geysers requires a favorable hydrogeology which exists in only a few places on Earth, and so they are fairly rare phenomena.
- About 1000 exist worldwide, with about half of these in Yellowstone National Park, USA.



<http://en.wikipedia.org/wiki/Geyser>

2) Hot Spring – Hot Waters Only

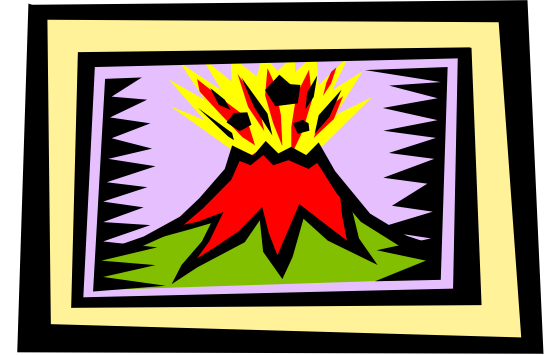


- **Hot springs** are pools of water that are warmed by underground springs, so they are always hot.

<http://www.eia.doe.gov/cneaf/solar.renewables/page/geothermal/geothermal.html>

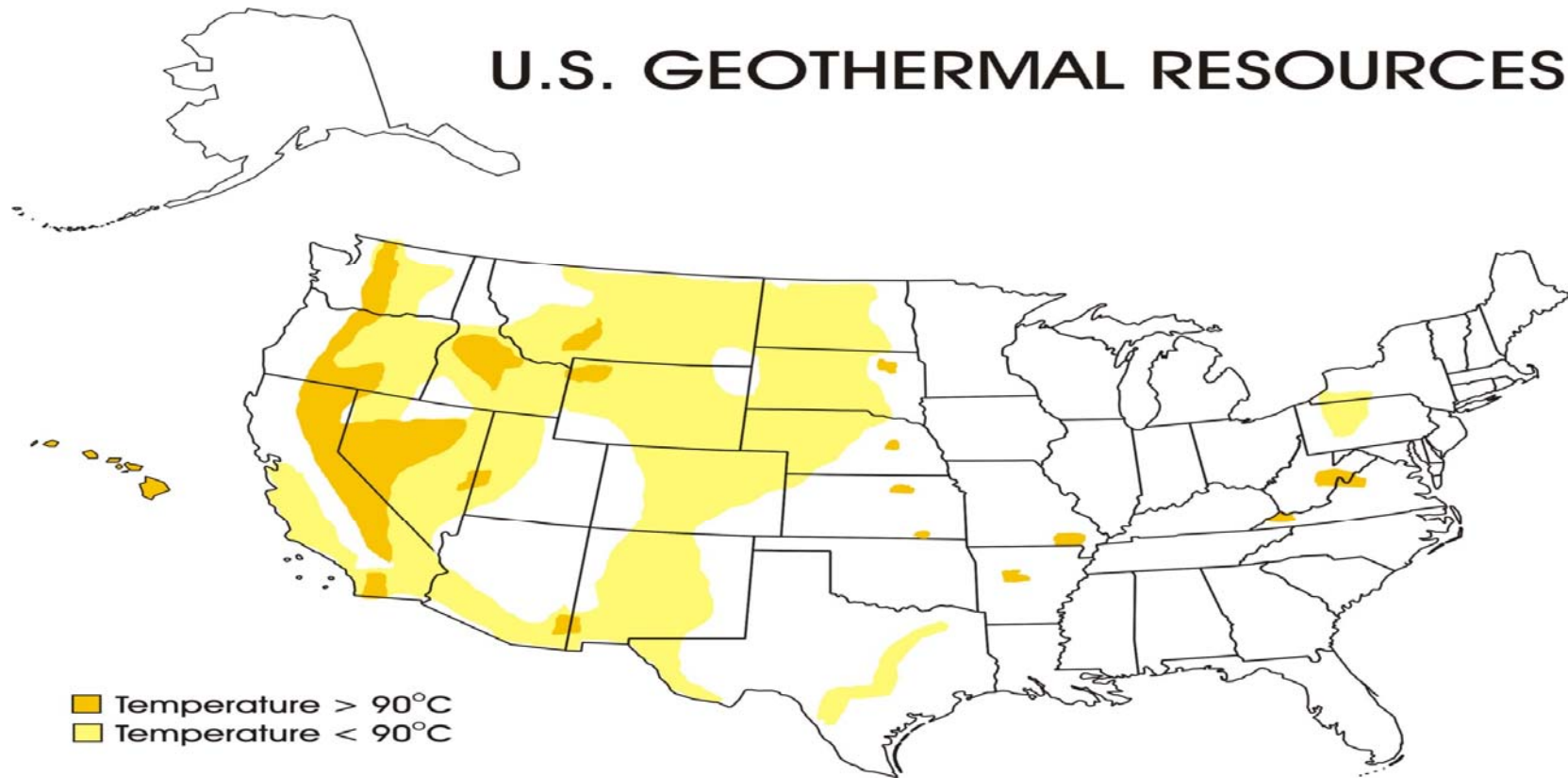
3) Volcanoes

- A volcano means hot magma is near the surface.
- The most active geothermal resources are usually found where **earthquakes** and **volcanoes** are concentrated.
- Most geothermal activity occurs in an area called the **Ring of Fire**.



Most geothermal plants in the United States are located in the western half of the country.

U.S. GEOTHERMAL RESOURCES



<http://www.deutsches-museum.de/ausstell/dauer/umwelt/img/geothe.jpg>

Extracting Geothermal Energy and Uses

➤ The heat energy can be brought to earth surface by following ways

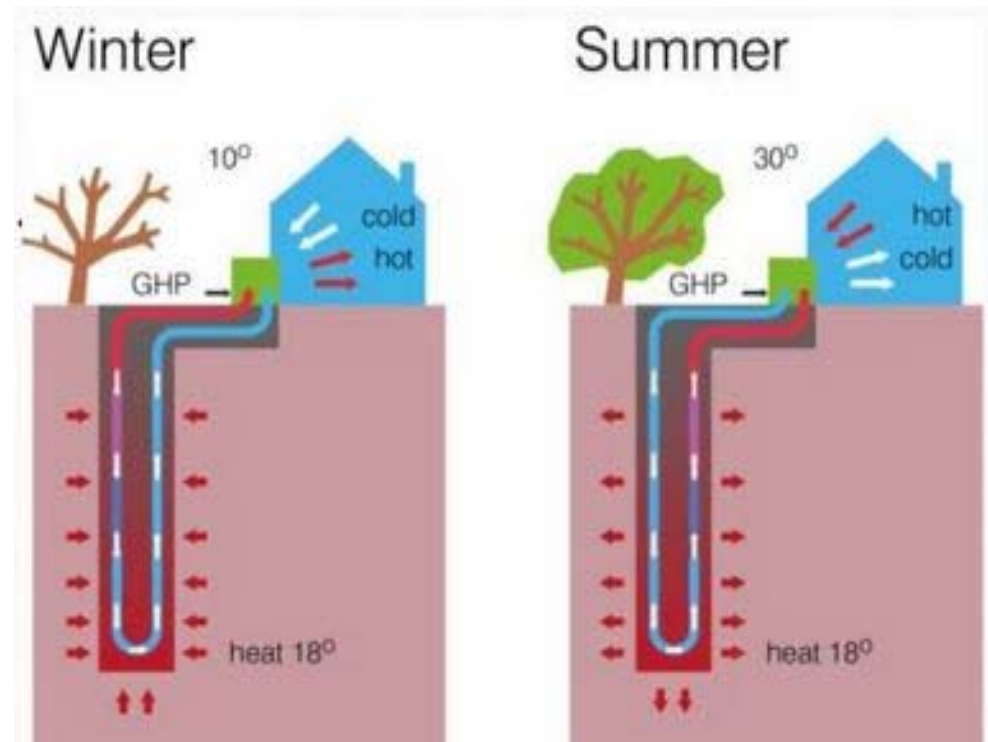
- 1) Directly from hot springs and geysers
- 2) Geothermal heat pump - is used to take the heat from the underground water to the substance that heats the house.

➤ Uses are broadly classified as

- 1) Direct Use
- 2) Indirect Use

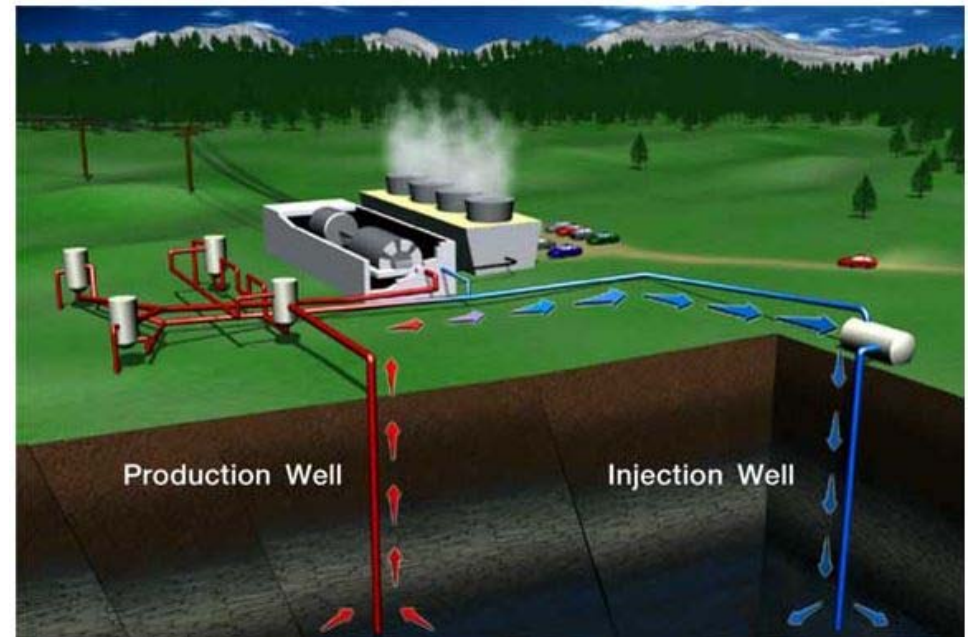
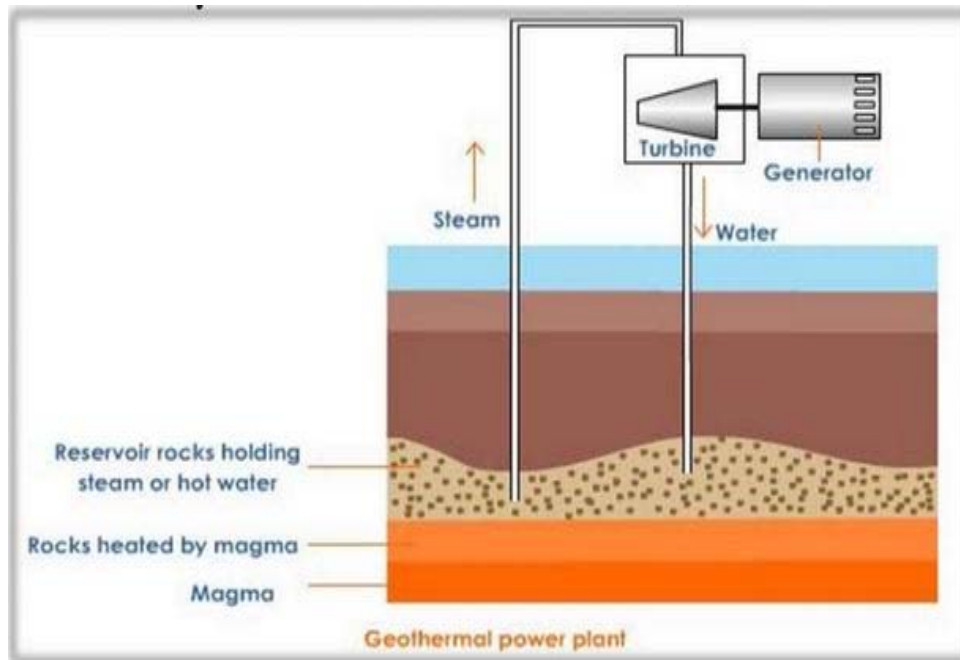
Direct Use of Geothermal Energy

- Source temp < 150 C
- Heating water at fish farms.
- It can provide heat for buildings.
- Air conditioning
- Raising plant in greenhouses, or drying crops.
- Provides heat to industrial processes.
- Basically uses little energy for heating thus saves money and reduces pollution.



Indirect Use of Geothermal Energy

- Mainly used for electricity generation. Source temp $> 150^{\circ}\text{C}$.
- Natural steam from the production wells power the turbine generator. The steam is condensed by evaporation in the cooling tower and pumped down an injection well to sustain production

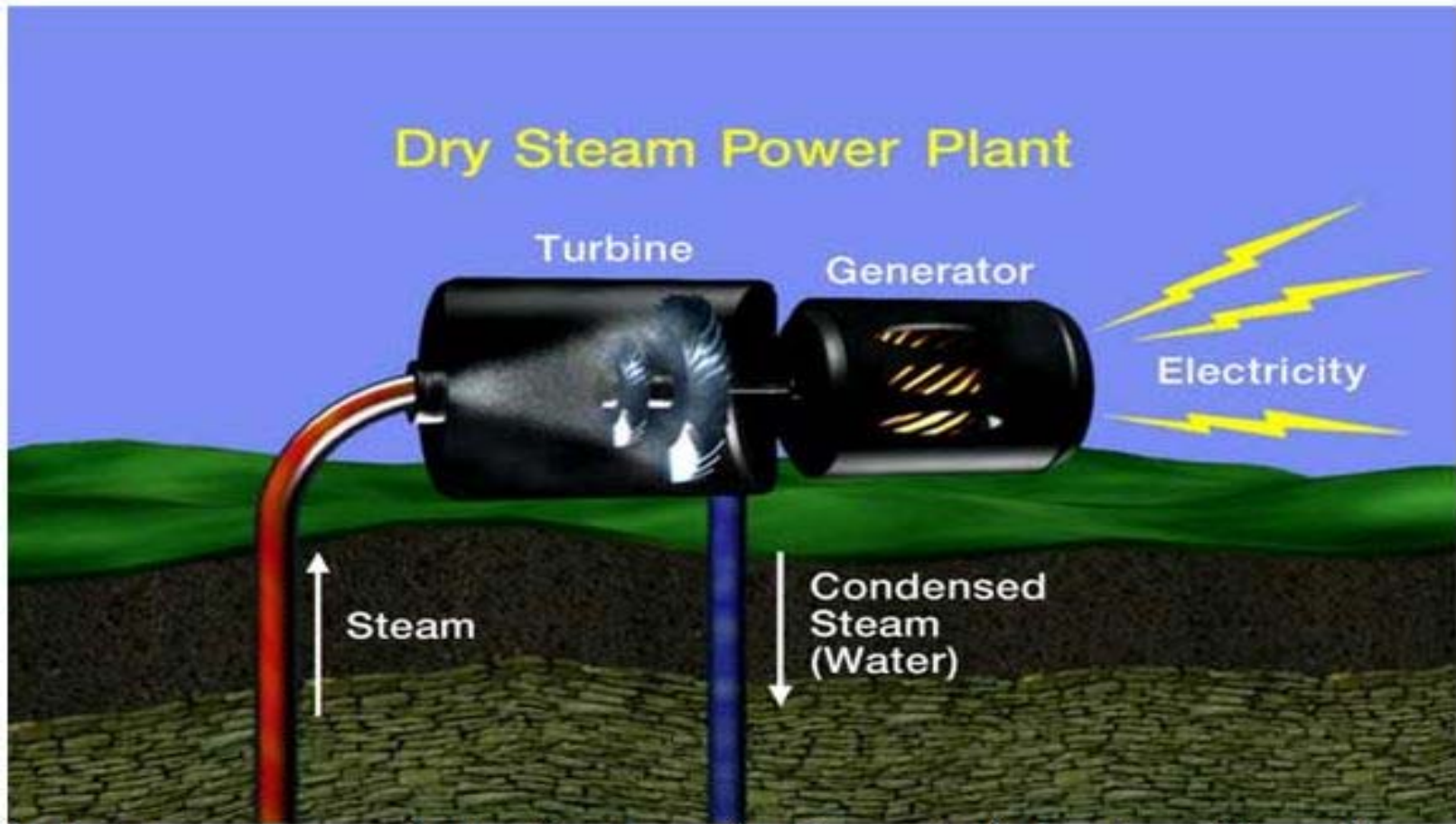


Electricity Generation

- The three basic types of geothermal electrical generation facilities are binary, dry steam (referred to as “steam”), and flash steam (referred to as “flash”).
- Electricity production from each type depends on reservoir temperatures and pressures, and each type produces somewhat different environmental impacts.

Dry Steam Geothermal Plant

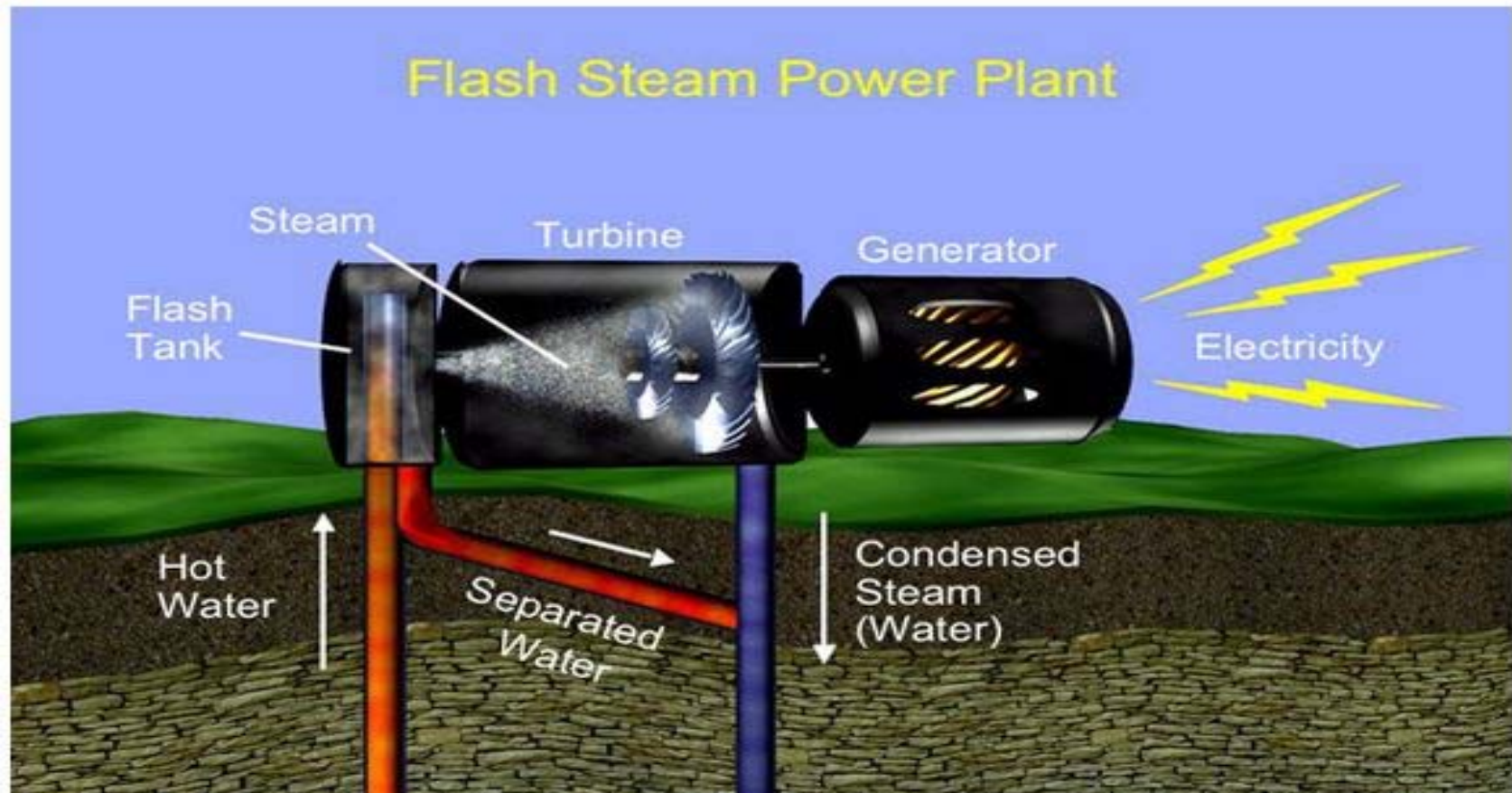
- In dry steam power plants, the steam (and no water) shoots up the wells and is passed through a rock catcher (not shown) and then directly into the turbine.
- The oldest type of Geothermal power plants used today.
- Usually geysers are the main source of Dry steam.
- Reservoirs which produces steam with small quantity of water uses this type of plant.
- Pure Dry steam drives turbine.
- Dry steam fields are rare.
- Operating at California, Italy, and Japan.



<http://geothermal.marin.org/geopresentation/slido49.htm>

Flashed Steam Plant

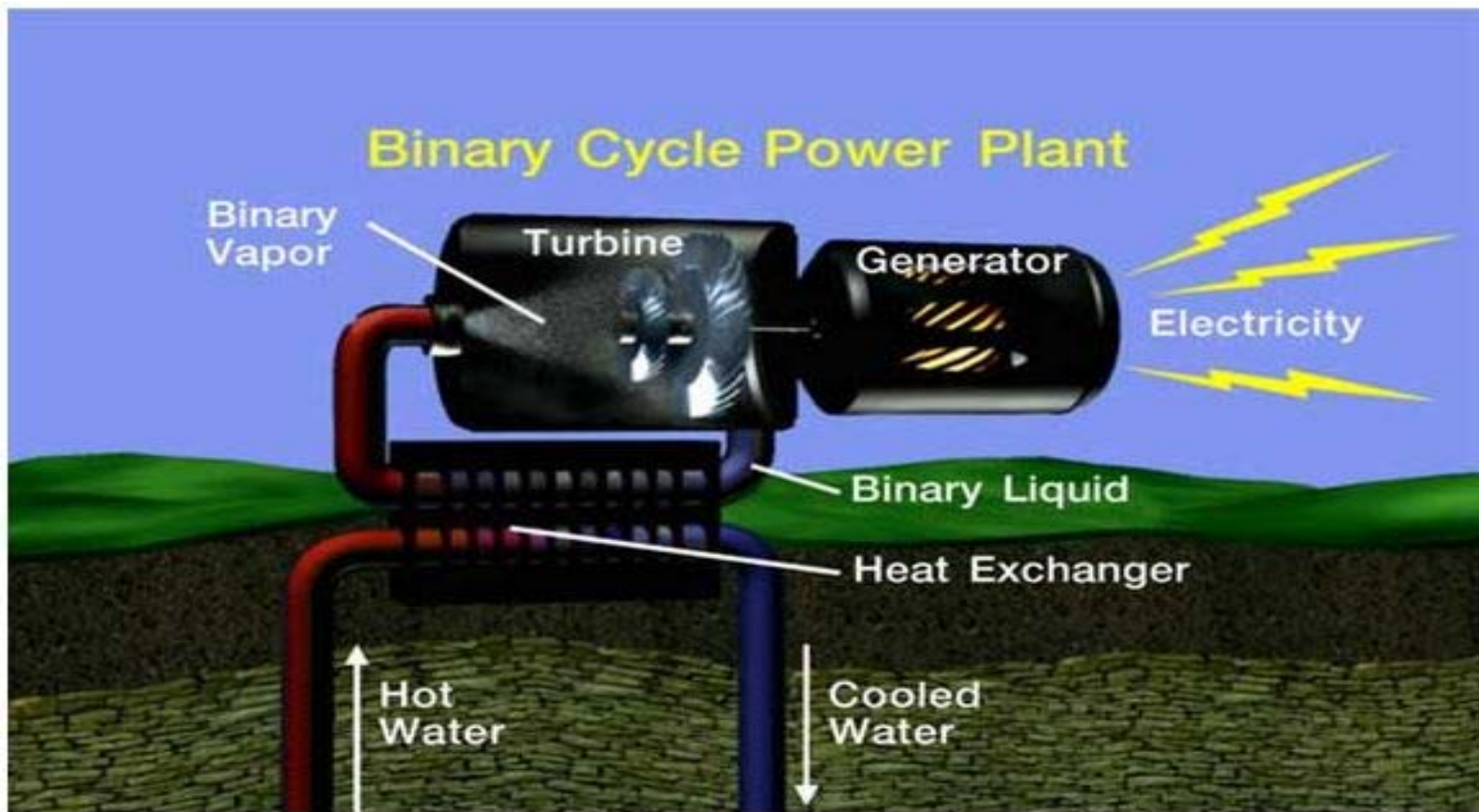
- Commonly used geothermal power plant.
- Flash steam power plants use hot water reservoirs.
- In flash plants, as hot water is released from the pressure of the deep reservoir in a flash tank, some of it flashes to steam.
- Pressure changing system is required.
- Basically steam drives turbines.
- Currently operating at Hawaii, Nevada, Utah and some other place.



<http://geothermal.marin.org/geopresentation/sldo54.htm>

Binary Cycle Power Plant

- Binary geothermal plants, these facilities reduce geothermal energy's already low emission rate to near zero.
- In the binary process, the geothermal water heats another liquid, such as isobutene, that boils at a lower temperature than water. The two liquids are kept completely separate through the use of a heat exchanger used to transfer the heat energy from the geothermal water to the "working-fluid."
- The secondary fluid vaporizes into gaseous vapor and (like steam) the force of the expanding vapor turns the turbines that power the generators.
- If the power plant uses air cooling the geothermal fluids never make contact with the atmosphere before they are pumped back into the underground geothermal reservoir, effectively making the plant emission free.
- Developed in the 1980s, this technology is already in use in geothermal power plants throughout the world in areas that have lower resource temperatures.
- The ability to use lower temperature resources increases the number of geothermal reservoirs that can be used for power production.



<http://geothermal.marin.org/geopresentation/sld059.htm>

Cost

- Direct use of geothermal energy is absolutely cheaper than any other energy resources.
- Cost of electricity generation depends upon certain factors :
 - Temperature and depth of resource
 - Type of resource (steam, liquid, mix)
 - Available volume of resources
 - Size and technology of plant

Cost - II

- The initial investment is high.
- But after certain period, the cost of electricity becomes comparable to other resources of energy.
- \$.05 to \$.08 per kWh
- Once the capital cost is recovered, the price can decrease to below \$.05 per kWh
- Basically most of the cost is related to resources exploration and plant construction.

Geothermal Energy In World

- 10,715 megawatts (MW) of geothermal power in 24 countries is online.
- The United States lead the world in geothermal electricity production with roughly 3,086 MW of installed capacity from about 77 power plants. Which is 2 times the production of solar and wind combined
- The Philippines is the second highest producer of geothermal power in the world, with 1,904 MW of capacity online; geothermal power makes up approximately 18% of the country's electricity generation.
- There is expected rise to 18,500 MW by end of 2015 due to large number of newly constructed projects.

Advantages of Geothermal

Geothermal Energy is **Renewable**

WHY ?

- The hot water we use will be replaced by rain.
- The heat inside the earth will always be there.
- More heat is made every day in the Earth's core.
- We won't run out of geothermal energy!

Advantages of Geothermal

- Environmentally very attractive
- Likely to remain an adjunct to other larger energy sources
- Provides clean and safe energy using little land
- Again it's renewable and sustainable
- Generates continuous, reliable "base load" power
- Conserves fossil fuels and contributes to diversity in energy sources
- Avoids importing and benefits local economies
- Offers modular, incremental development and village power to remote sites.

Disadvantages of Geothermal

- Not widespread source of energy
- High installation cost
- Can run out steam
- Earthquakes
- Power plants that do not inject the cooled water back into the ground can release H_2S , the “rotten eggs” gas. This gas can cause problems if large quantities escape because inhaling too much is fatal.
- There is the fear of noise pollution during the drilling of wells.

Conclusion

- Data compiled from a variety of sources point to geothermal energy as an environmental option for new power generation that is far better than other energy sources such as fossil fuels.
- In addition, geothermal remains as environmentally friendly as most other renewable sources, while simultaneously offering reliability and a source of base load power that is unique among most other renewable options available.
- While currently used at only a fraction of its potential, geothermal energy can substantially contribute to the energy needs of the twenty-first century.
- As geothermal energy production is refined and expanded, the benefits continue to grow.
- Geothermal energy can provide the clean, reliable, and plentiful renewable energy resource for our nation and for the world.

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