

GEO THERMAL ENERGY

**ARIZONA PUBLIC SERVICE
COMPANY**



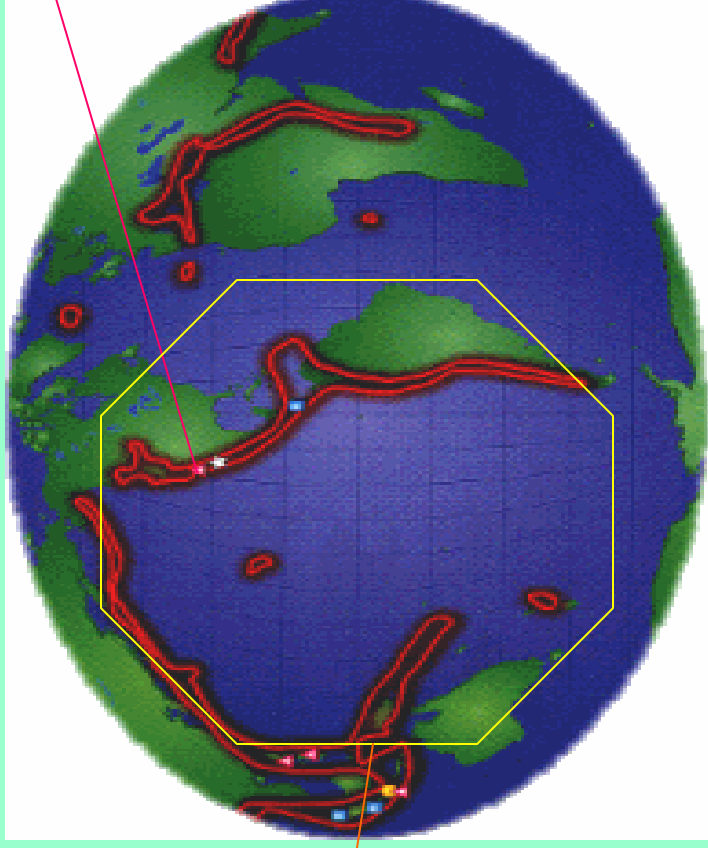
WHAT DOES THE WORD "GEO THERMAL" MEAN?

Geo = Earth

Thermal = Heat

WHAT IS GEOTHERMAL ENERGY?

*Energy that can be extracted from the heat in the earth
Conditions are most favorable for geothermal activity where
the earth's tectonic plates collide and one slides beneath
another. The best example of these hot regions is the Pacific
Ring of Fire*



Arizona

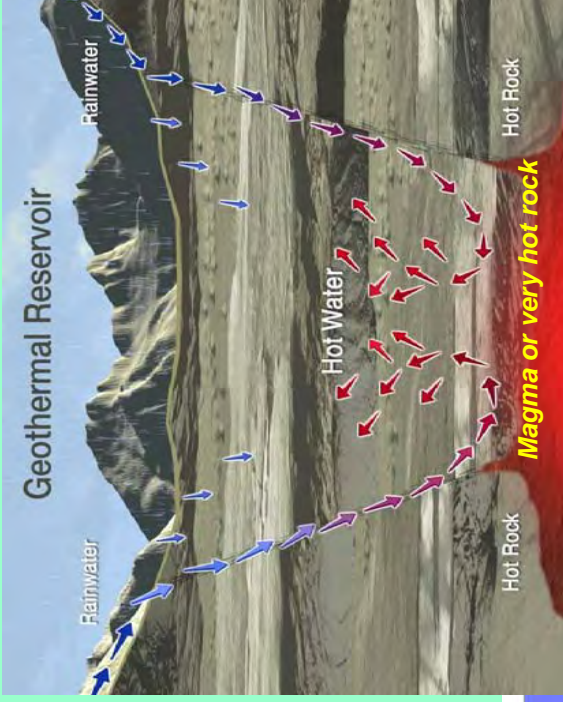
Pacific
Ring of fire



HOW DOES GEOTHERMAL HEAT GET UP TO EARTH'S SURFACE?

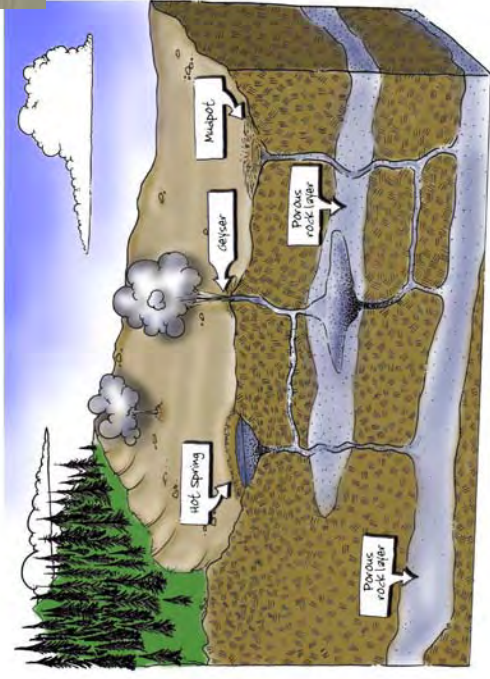
➤ Conduction

Heat from the Earth's interior flows outward. It is transferred to the outer layer of rock or the crust.



➤ Convection

In some regions, the mantle beneath the crust may be hot enough to partly melt and create magma. Magma rising upward out of the mantle can bring intense shallow heat into the crust



Rainwater seeping downward through pores and crevices in the crust to depths of a mile or more is heated. The heated water may be stored at depth in geothermal reservoirs, or the hot water may flow upward out the reservoirs to the surface as hot springs, or boil near the surface to create geysers, fumaroles, and mudpots.

HOW HAVE PEOPLE USED GEOTHERMAL ENERGY IN THE PAST?

- **Bathing:** Ancient civilizations used hot springs for bathing
- **Medical Therapy:** Early Romans used geothermal water to treat eye and skin disease
- **Cooking:** Native Americans and others used geothermal water for cooking
- **Heating:** Early Romans used geothermal water to heat their homes in Pompeii



HOW DO WE USE GEOTHERMAL ENERGY TODAY?

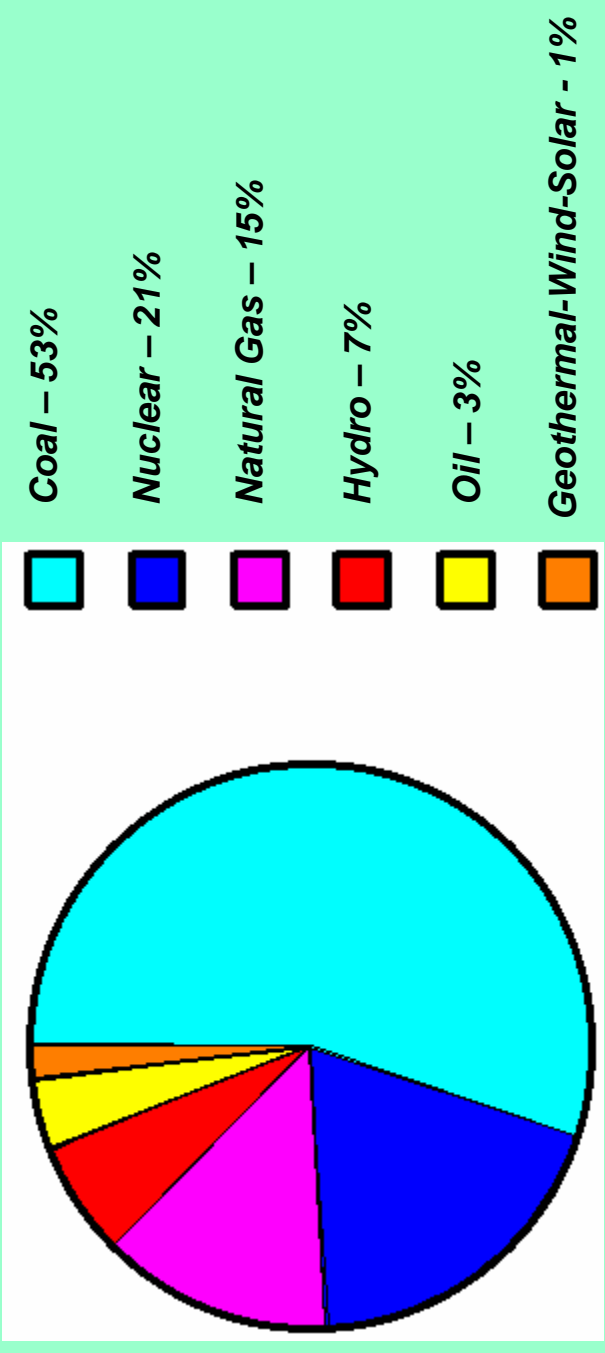
- *Space Heating/Cooling*
- *Water Heating / Spas*
- *Aquaculture : Fish, Shrimp, Abalone, Alligators*
- *Drying of fruits / vegetables / lumber*
- *Industrial Uses: Dying of cloth, washing wool, piping under sidewalks to keep from freezing, manufacturing paper*
- *Greenhouses: Vegetables, flowers and other crops*
- *Electricity Generation*

TILAPIA FARM SAFFORD

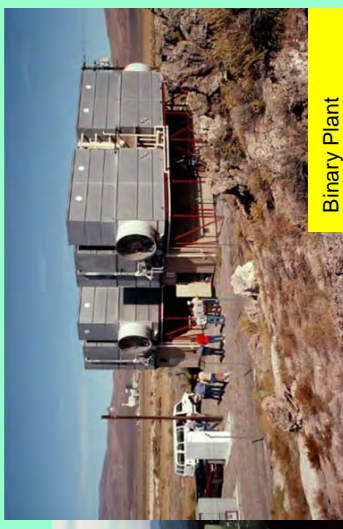


HOW MUCH ELECTRICITY IS GENERATED IN THE U.S. FROM GEOTHERMAL ENERGY?

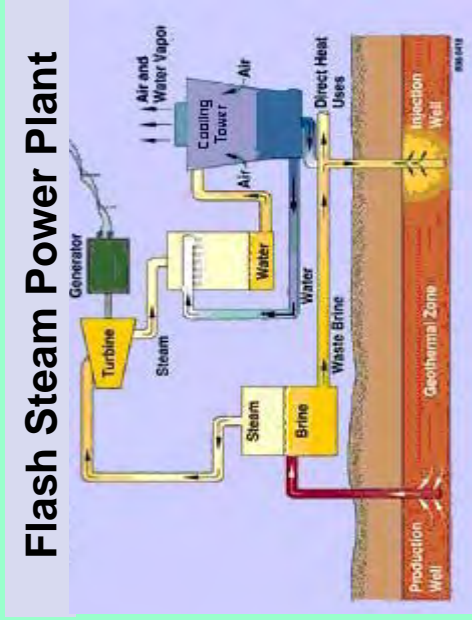
- 2700 MW Today
- 0.4% of all electrical generation
- Estimated additional capacity available 5,000 – 18,000 MW



2003 U.S. Power Resources

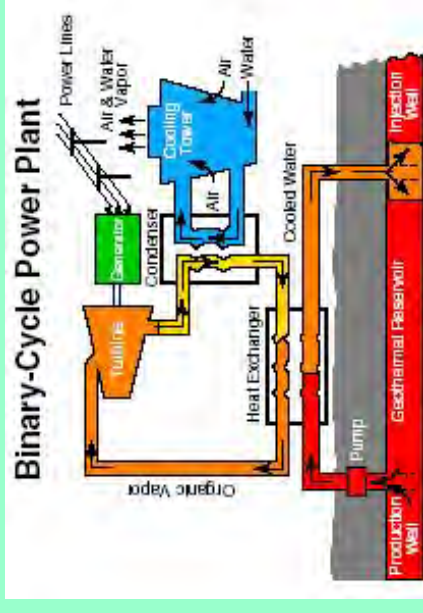


HOW IS ELECTRICITY GENERATED USING GEOTHERMAL ENERGY?

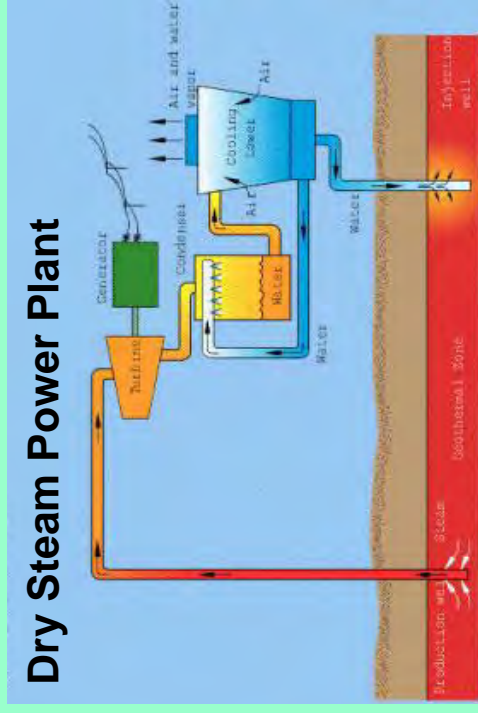


The geothermal fluids are brought to the surface through wells that are drilled deep into the earth. The hot water (300 °F or more) is highly pressurized. As the water pressure is reduced during transit to the surface, 30 – 40% of the water flashes (explosively boils) to steam. The steam is fed to a turbine/generator to produce electricity. The remaining water is returned into the earth to help maintain pressure and prolong the productivity of the geothermal well.

A few geothermal reservoirs produce mostly steam and very little water. The steam shoots directly through a rock-catcher and into the turbine.

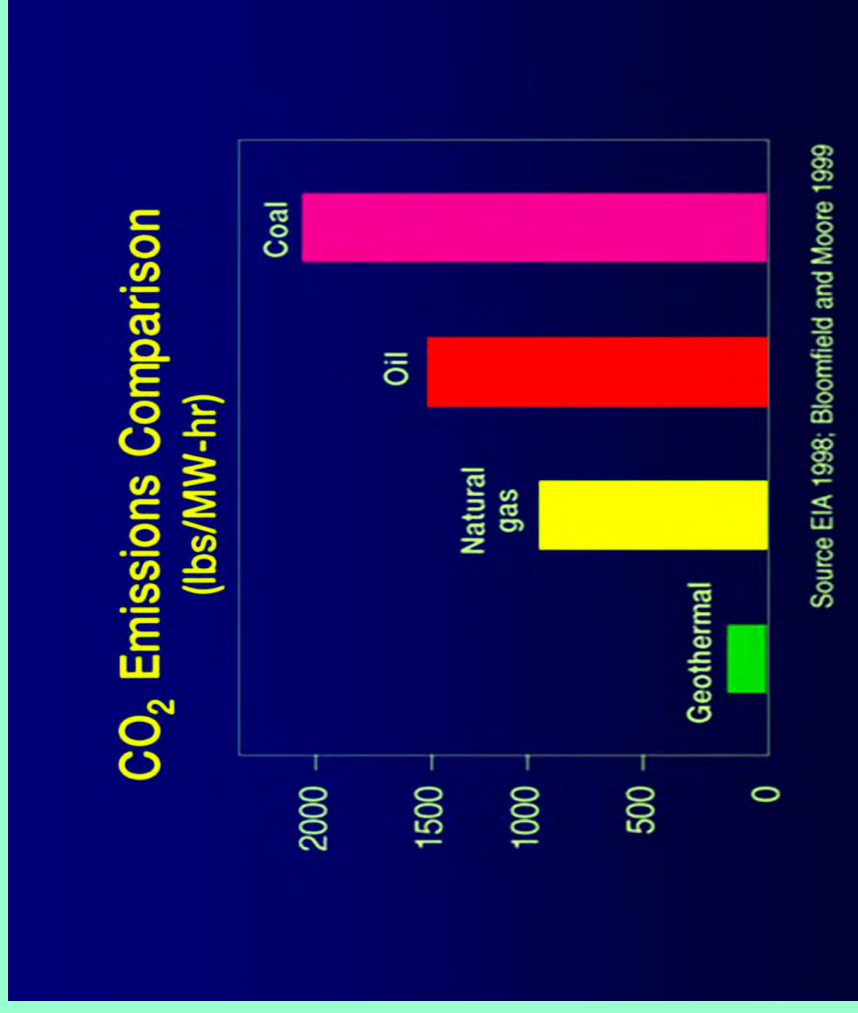


Geothermal water is passed through a heat exchanger to heat a secondary fluid that vaporizes at a lower temperature than water. The fluid vapor spins the turbine/generator, is condensed back to liquid and re-vaporized at the heat exchanger.



WHAT ARE SOME OF THE ADVANTAGES OF USING GEOTHERMAL ENERGY TO GENERATE ELECTRICITY?

- **Clean:**
No emissions, safe to use
- **Reliable:**
Continuous, reliable base-load power
- **Sustainable / Reusable:**
Water can be recycled back into the earth and reused
No other fuel mixture required to create electricity
- **Land Conservative:**
No major land requirements. Can be integrated into the local area with no adverse effects
- **Flexible / Modular:**
Geothermal power plants can have modular designs, with additional units installed in increments when needed to fit growing demand for electricity

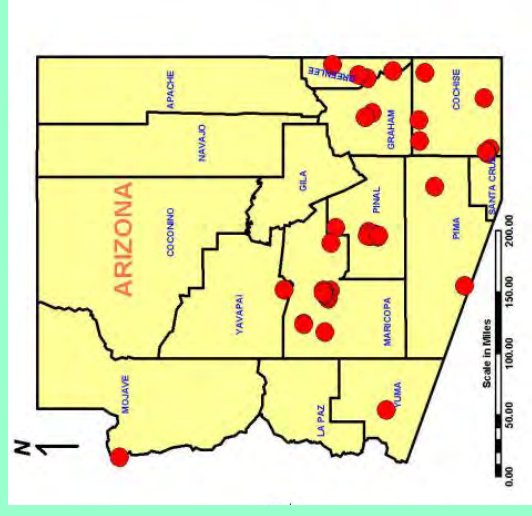
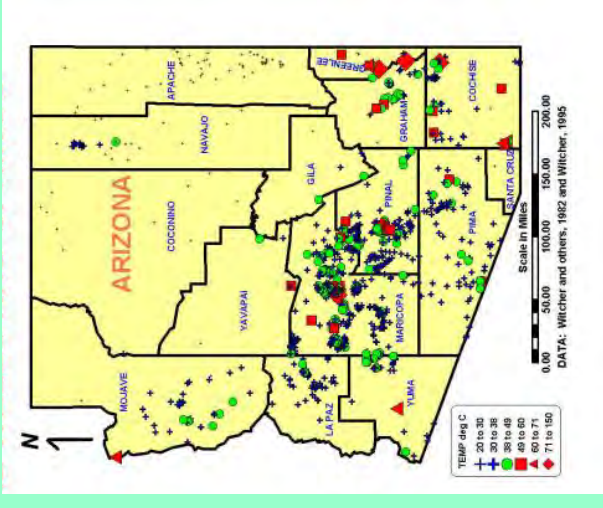
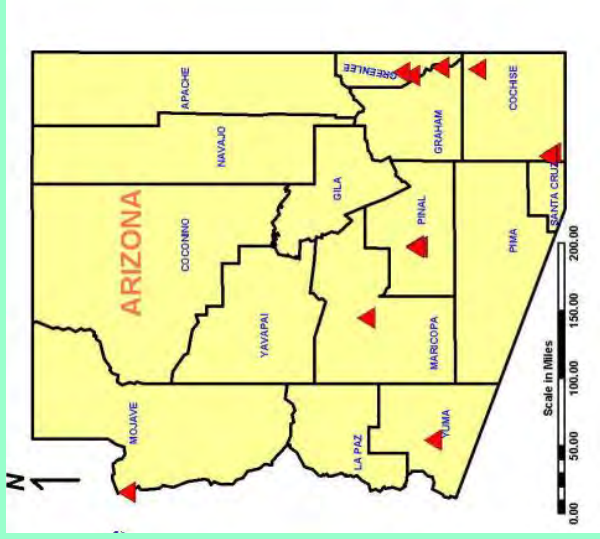


ARIZONA LOCATIONS SHOWING TEMPERATURES AND POSSIBLE POWER PRODUCTION

Arizona Thermal Wells and Springs

- Over 20 geothermal aquaculture businesses use hot water to grow tilapia, catfish, and shrimp.
- Most geothermal aquaculture is in the Hyder Valley, around Gila Bend, at Marana, and in the vicinity of Safford.

Higher temperature springs and wells (greater than 50° C) occur in areas that may have potential for space heating and geothermal greenhousing



- Some of the areas shown with wells and springs greater than 60° C may be underlain by reservoirs with 120 - 160° temperatures and be suitable for small scale (≤ 1 to 5 MWe) binary electric power generation or refrigeration
- Best potential is found in the Clifton and Gillard Hot Springs areas.



HOW DOES ARIZONA USE GEOTHERMAL ENERGY TODAY?

- Aquaculture
 - Gila Bend
 - Shrimp Farms
 - Hyder
 - Tilapia Fish Farms
 - Marana
 - Winter Citrus Irrigation

- Hot Springs
 - Tonopah
 - Safford

BUCKHORN BATHS MESA



SHRIMP FARM GILA BEND



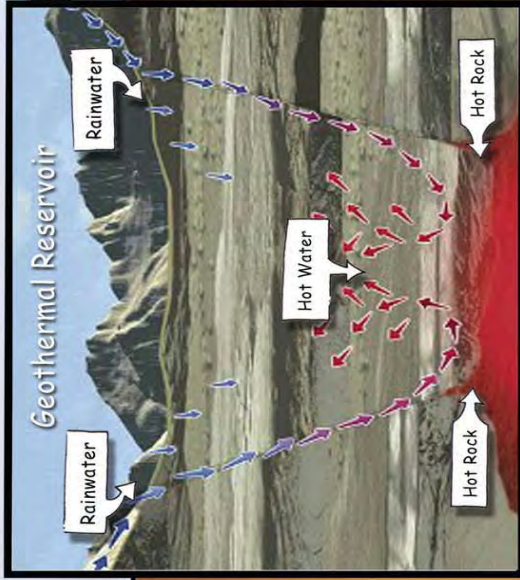
TILAPIA FARM HYDER



TILAPIA FARM SAFFORD



GEO THERMAL



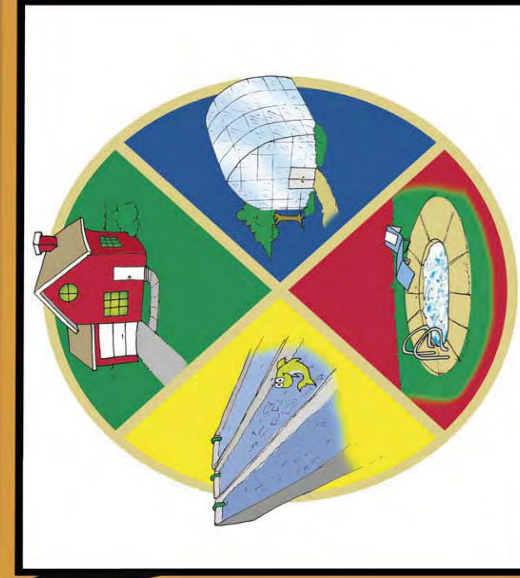
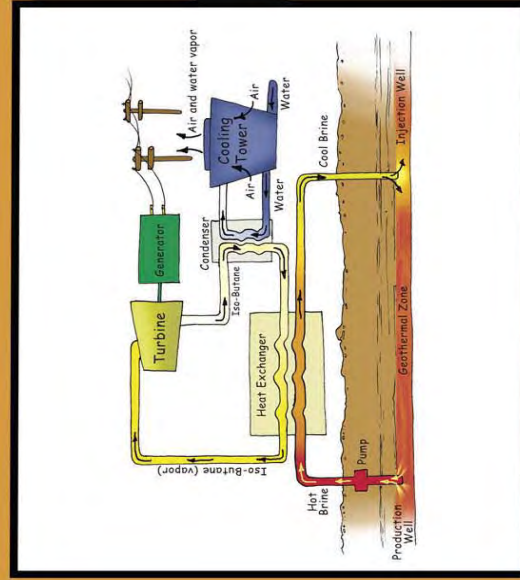
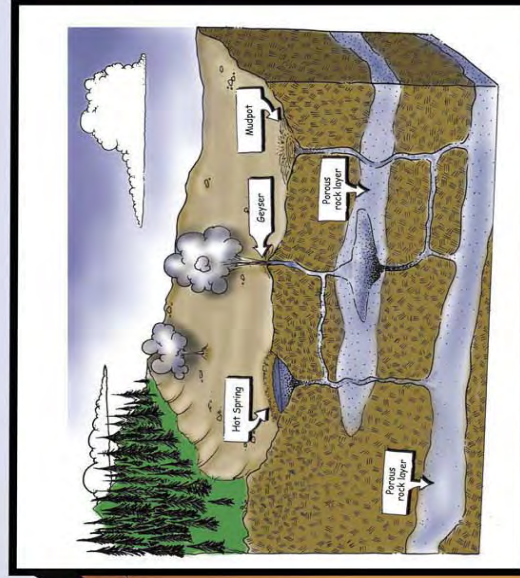
Geothermal Energy is heat (thermal) derived from the earth (geo). It is the thermal energy contained in the rock and fluid that fills the fractures and pores within the rock in the earth's crust. Visual, surface indications of the presence of geothermal activity include geysers, fumaroles, mudpots, hot springs and volcanoes.

Depending on the geophysical conditions that exist at a geothermal site, different technologies can be used to utilize the geothermal energy. Modern applications include greenhouses, aquaculture, home and business heating, and electricity generation.

Electricity generation is accomplished by drilling wells into the earth to tap into the geothermal energy reservoirs. The thermal energy available in the reservoirs can be used to power electricity generation equipment.

One method of generating electricity is by using the geothermal energy to power a Binary-cycle Power Plant. This type of plant is used for relatively low temperature geothermal reservoirs in the range of 250° to 300° F. In this plant, geothermal waters are passed through a heat exchanger to heat a secondary working fluid that vaporizes at a lower temperature than water. The working fluid vapor spins a turbine/generator and is condensed back to liquid before being re-vaporized in the heat exchanger again. The heat-depleted geothermal water is injected back into the geothermal reservoir.

Other methods for generating electricity include Flash Steam, Dry Steam and Hot Dry Rock power plants.



Additional Sources of Information

<http://www.eere.energy.gov/geothermal/>

<http://www.energyquest.ca.gov/index.html>

<http://www.azgs.az.gov/Summer2001.htm>

http://www.energy.gov/engine/content.do?BT_CODE=ENERGYSOURCES

<http://geothermal.marin.org/hotsites.html>

<http://www.geothermal.marin.org/>

<http://lsa.colorado.edu/summarystreet/texts/geothermal.htm>

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