Renewable Energy Technologies

Geothermal Energy

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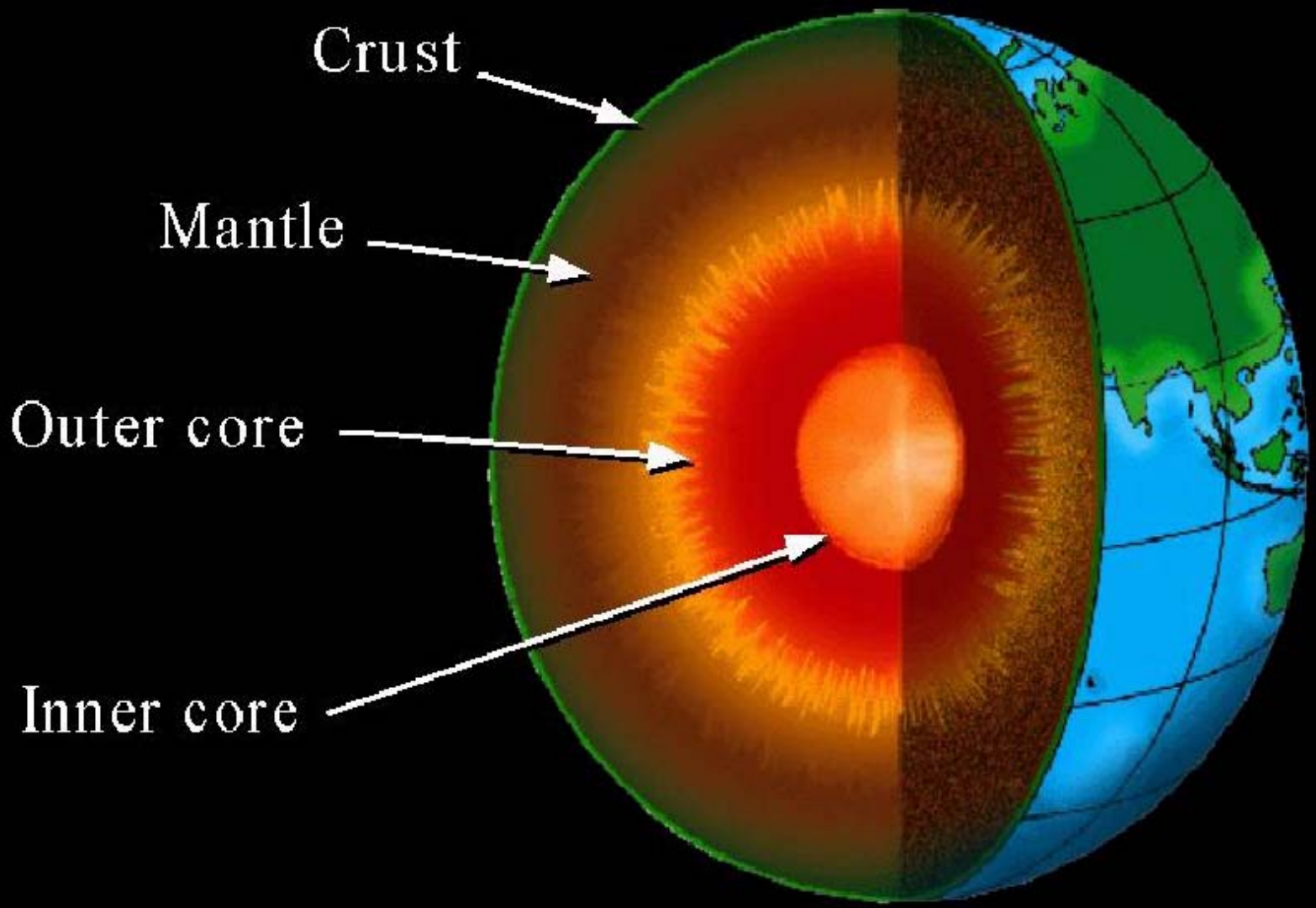
Geothermal Energy is Heat from the Earth.

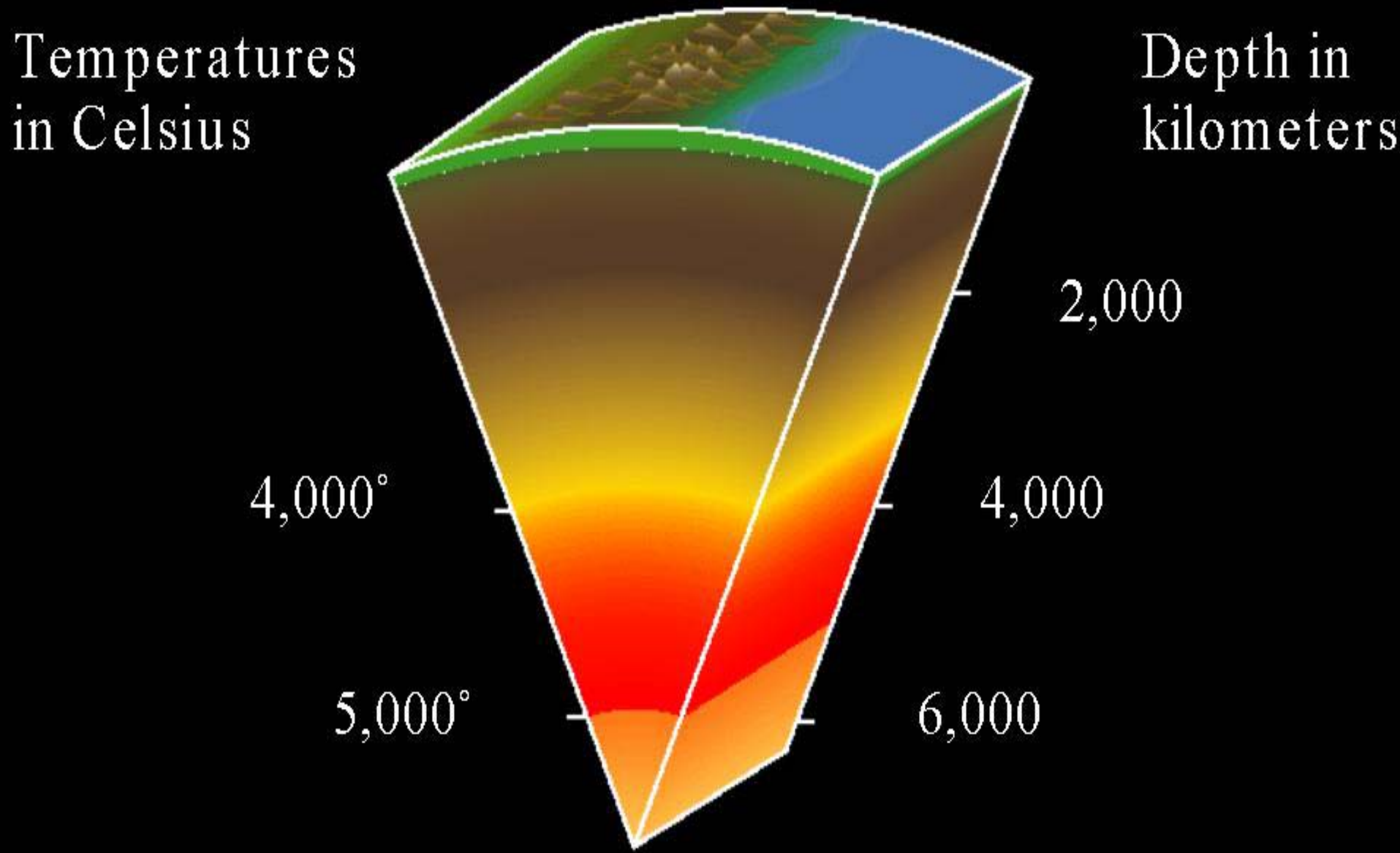
How Geothermal Energy is Used:

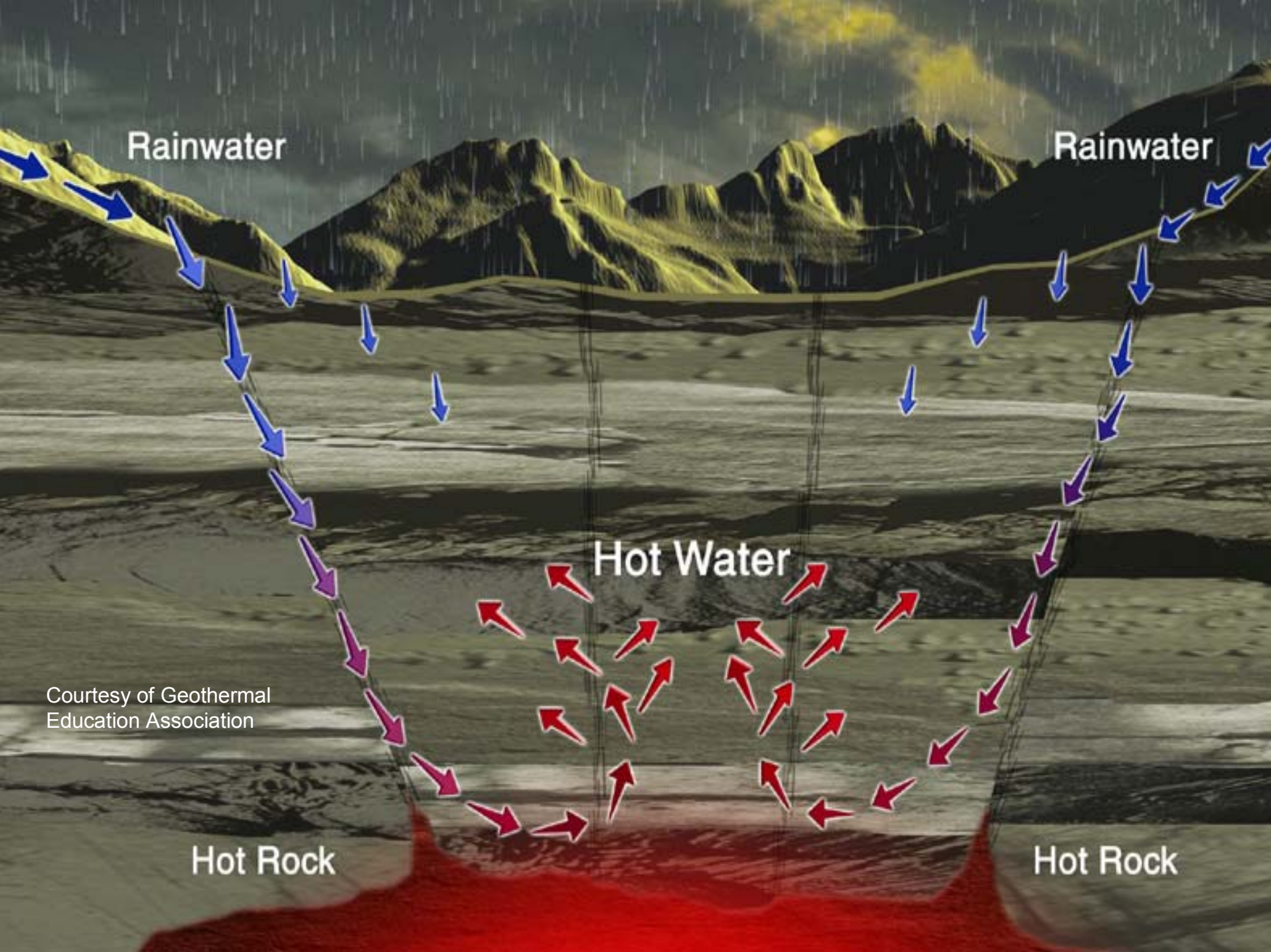
- Electricity Generation
- Direct Thermal Use
- Geothermal Heat Pumps, also called Geoexchange Units or Ground-Coupled Heat Pumps.

The Earth

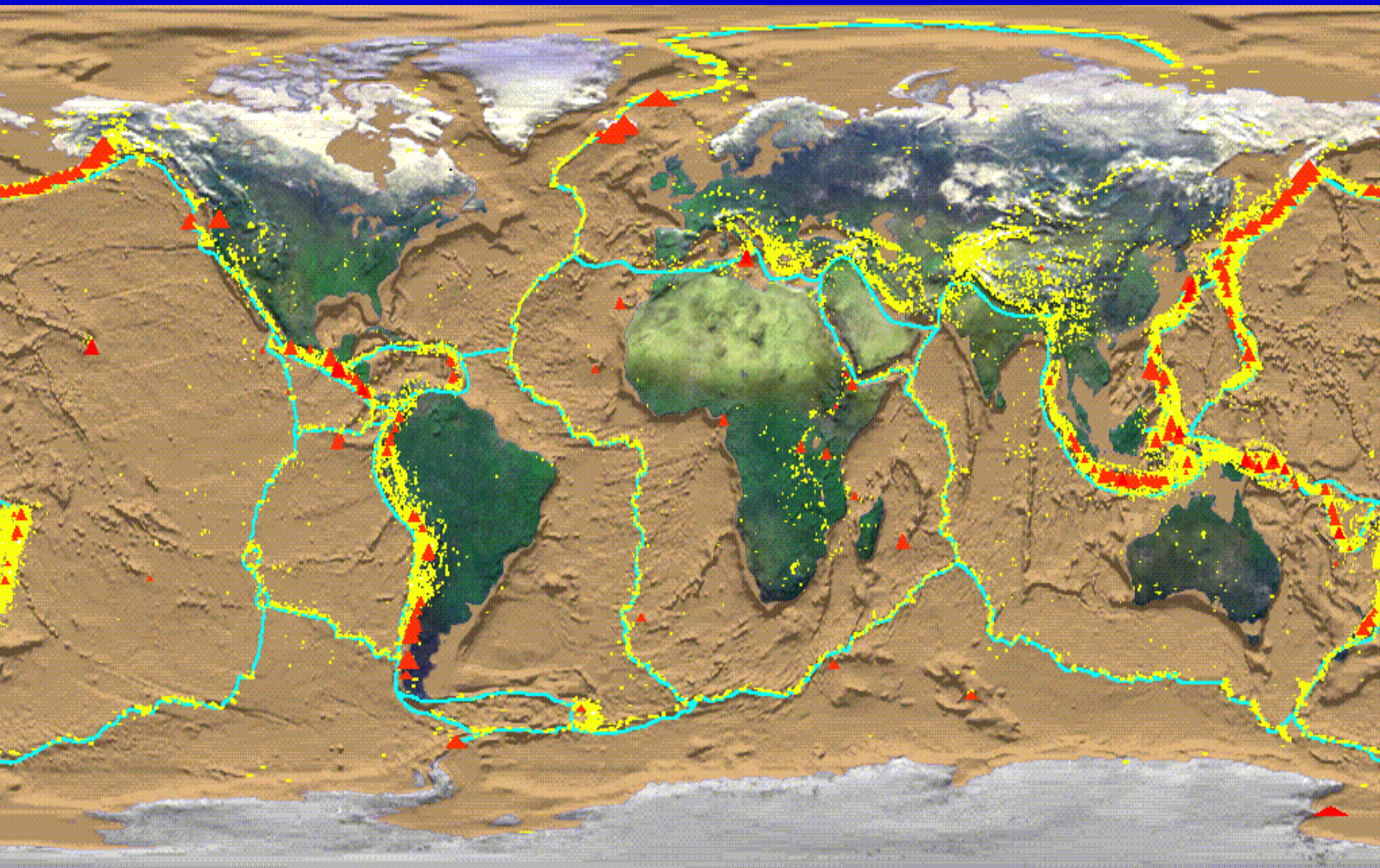


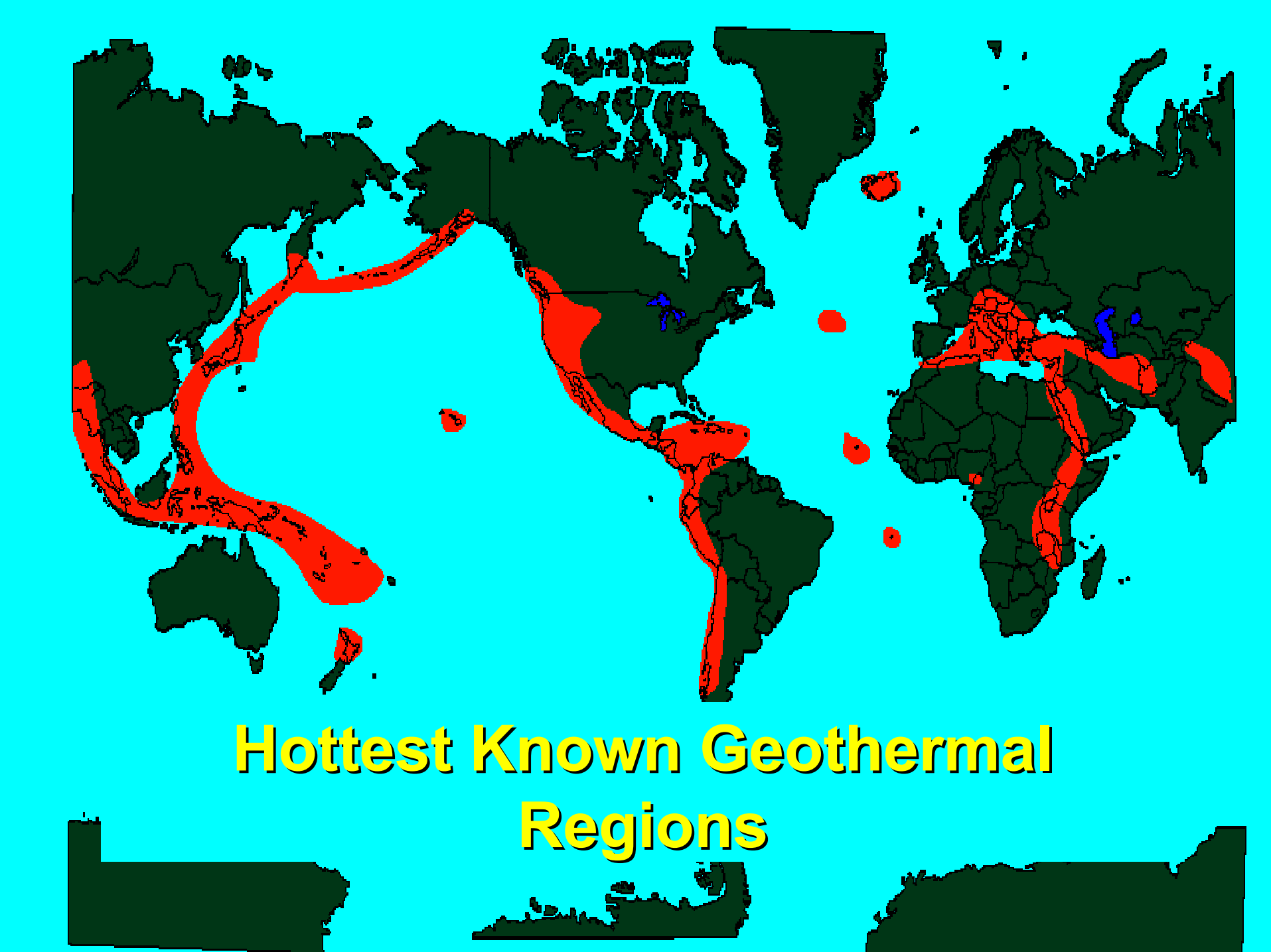
Temperatures in the Earth

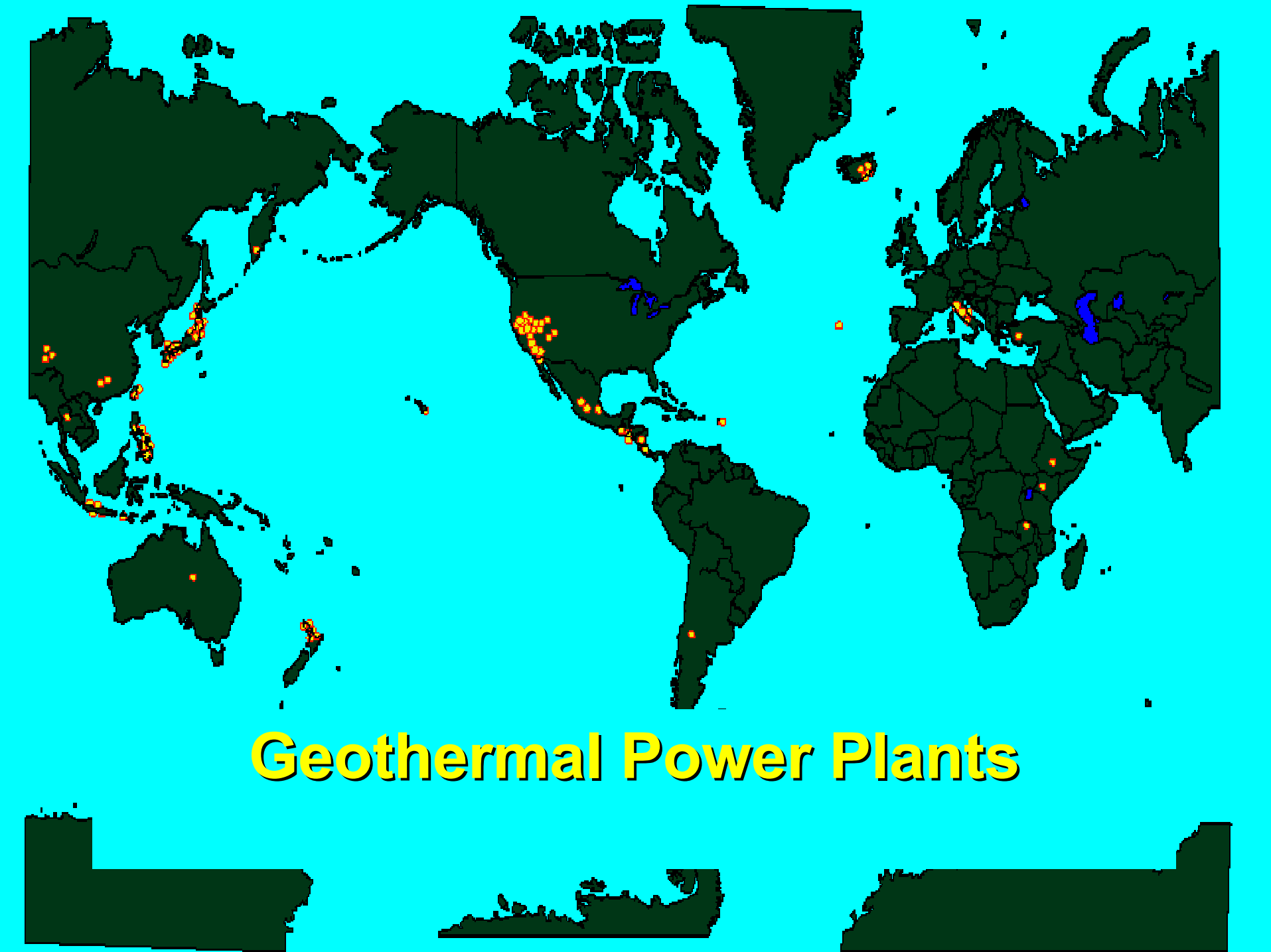



Rainwater
Rainwater
Hot Water
Courtesy of Geothermal
Education Association
Hot Rock
Hot Rock

Tectonic Plate Boundaries

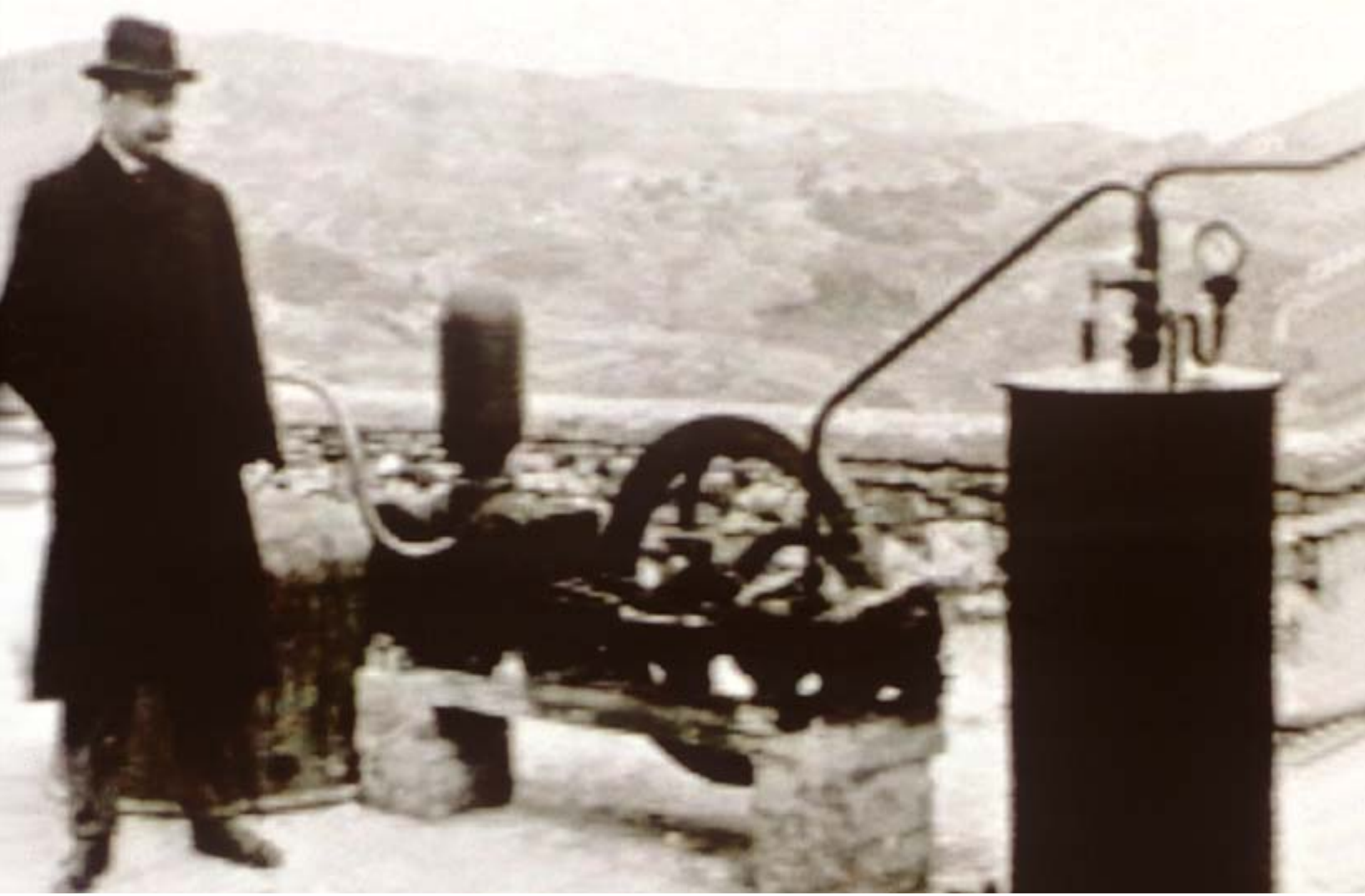



Hottest Known Geothermal
Regions


Geothermal Power Plants

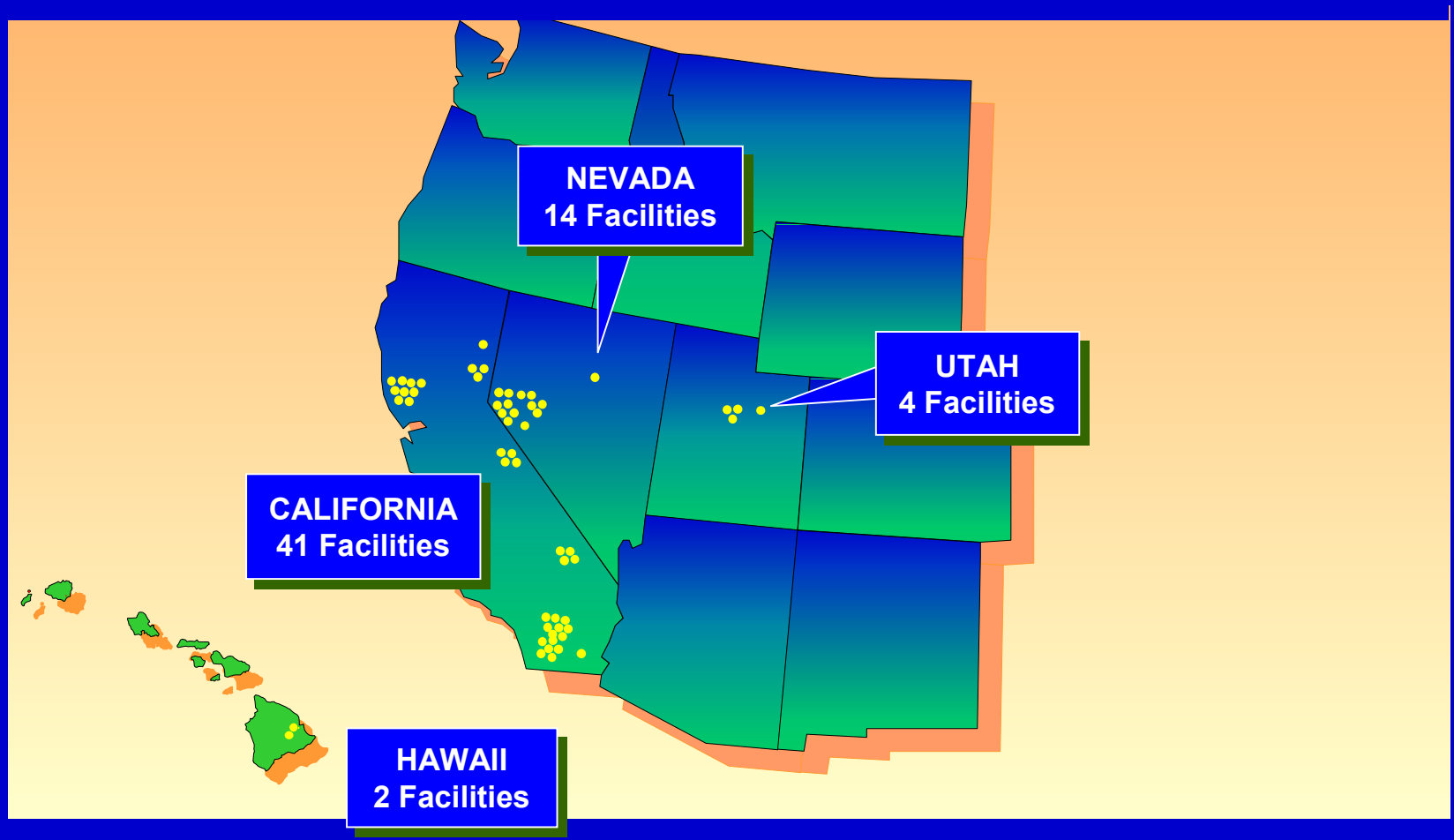
History of Geothermal Electricity

- Experiments began in Lardarello, Italy in 1904
- First U.S. plant at The Geysers in 1920s; first commercial plant in 1960

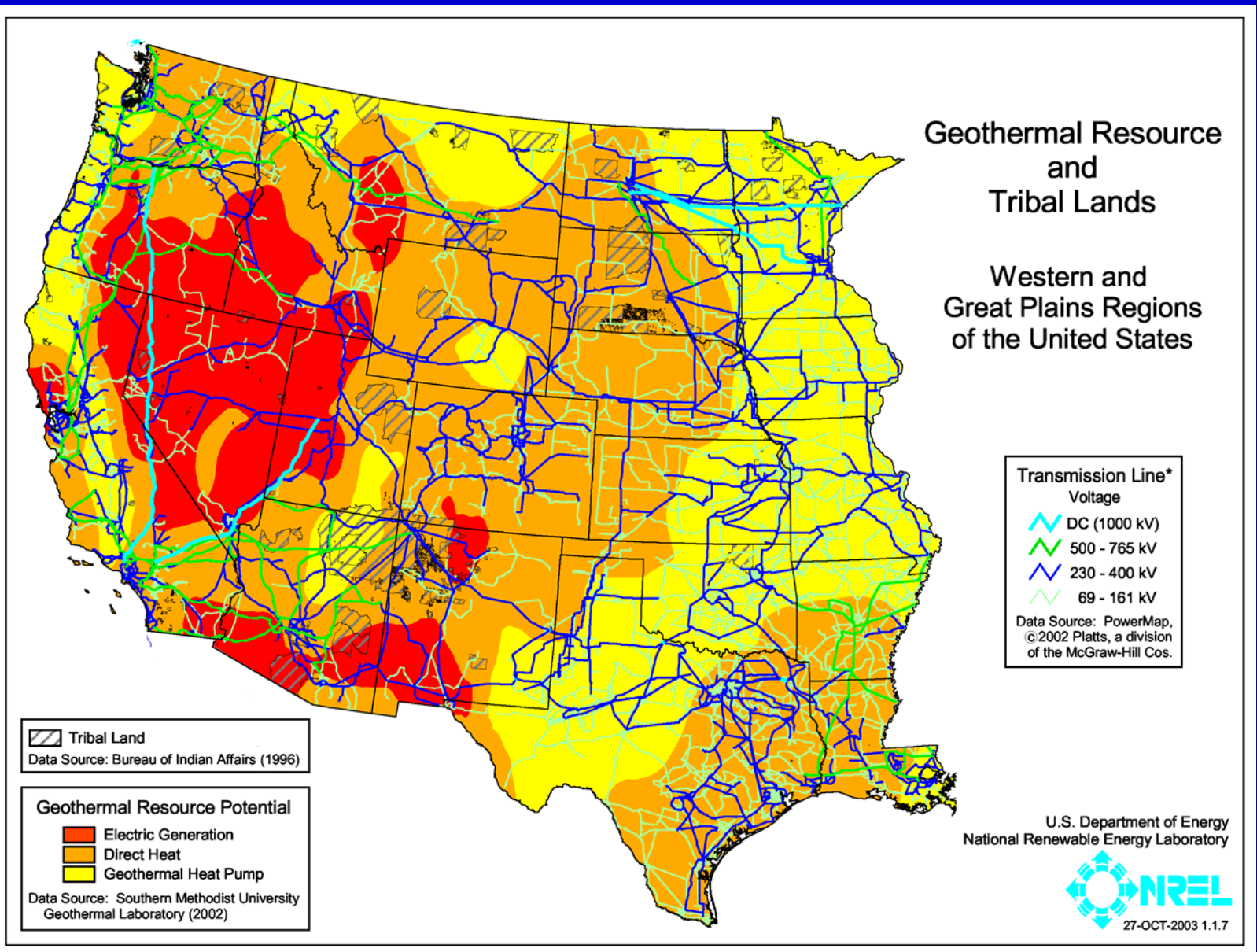


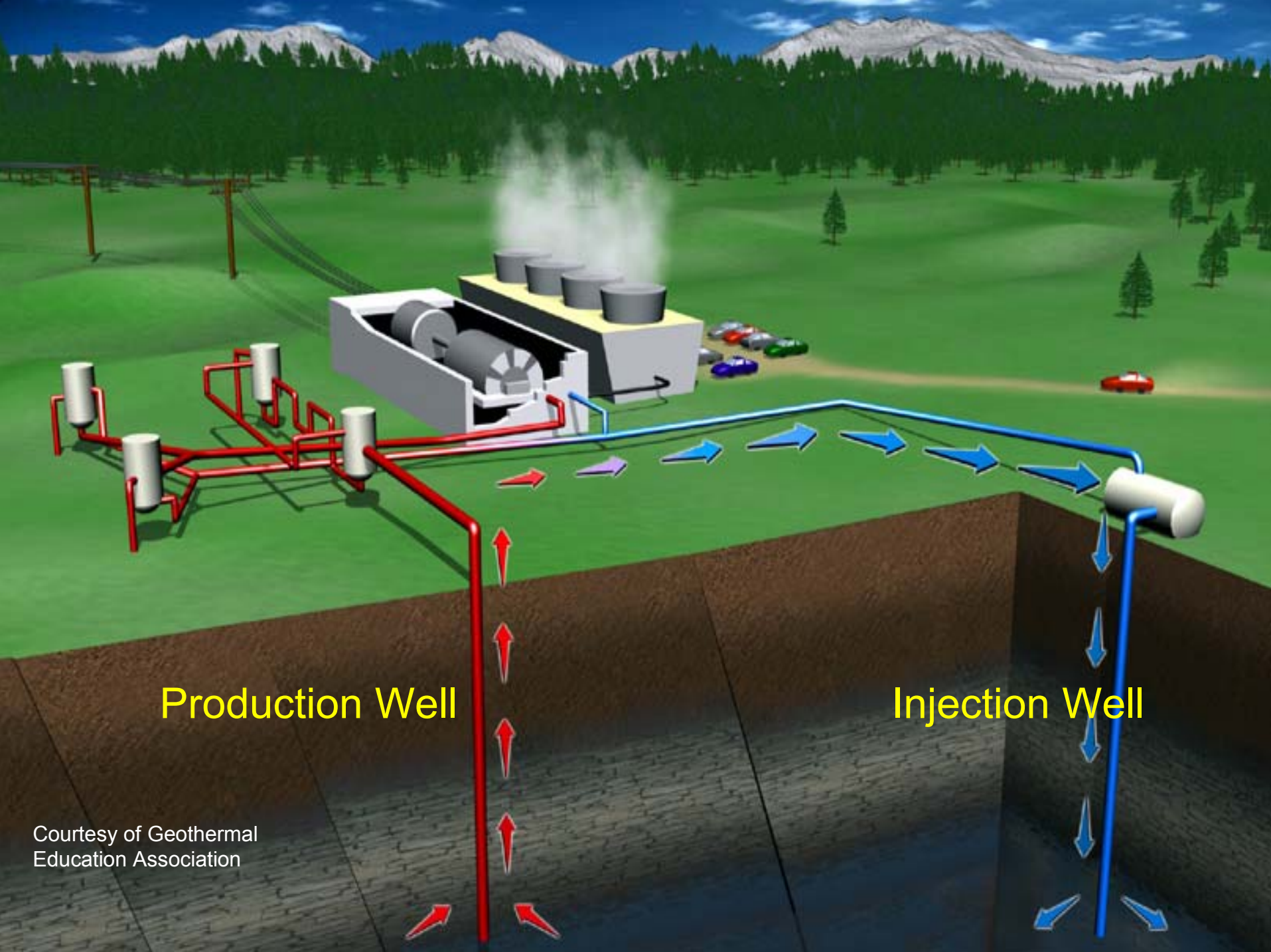
First Geothermal Power Plant, 1904, Larderello, Italy.

U.S. Geothermal Power Generation Sites



Native Americans have been using geothermal energy for many years.


Geothermal Resource
and
Tribal Lands
Western and
Great Plains Regions
of the United States
Transmission Line*
Voltage
DC (1000 kV)
500 - 765 kV
230 - 400 kV
69 - 161 kV
Data Source: PowerMap,
©2002 Platts, a division
of the McGraw-Hill Cos.
Tribal Land
Data Source: Bureau of Indian Affairs (1996)
Geothermal Resource Potential
Electric Generation
Direct Heat
Geothermal Heat Pump
Data Source: Southern Methodist University
Geothermal Laboratory (2002)
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
27-OCT-2003 1.1.7



Courtesy of Geothermal
Education Association

Advantages

- Dispatchable, 24–hour, base-load electricity
- Very reliable
- 90 to 95% availability
- Environmentally sound (e.g., low emissions)
- Virtually inexhaustible with smart resource management practices
- Relatively low cost (~4 to 8 cents/kWh)

Geothermal Energy Getting Cheaper

1980: 10-16 cents/kWh

2000:
4-7 cents/kWh

- Improved technology
- Reduced drilling costs
- Experience reduces risk

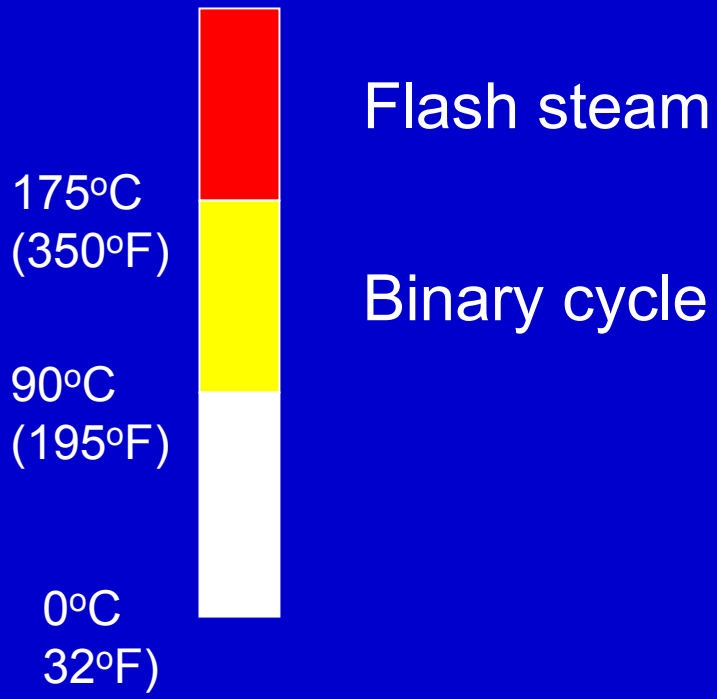
2007 Goal: 3-5 cents/kWh

Significant Energy Production

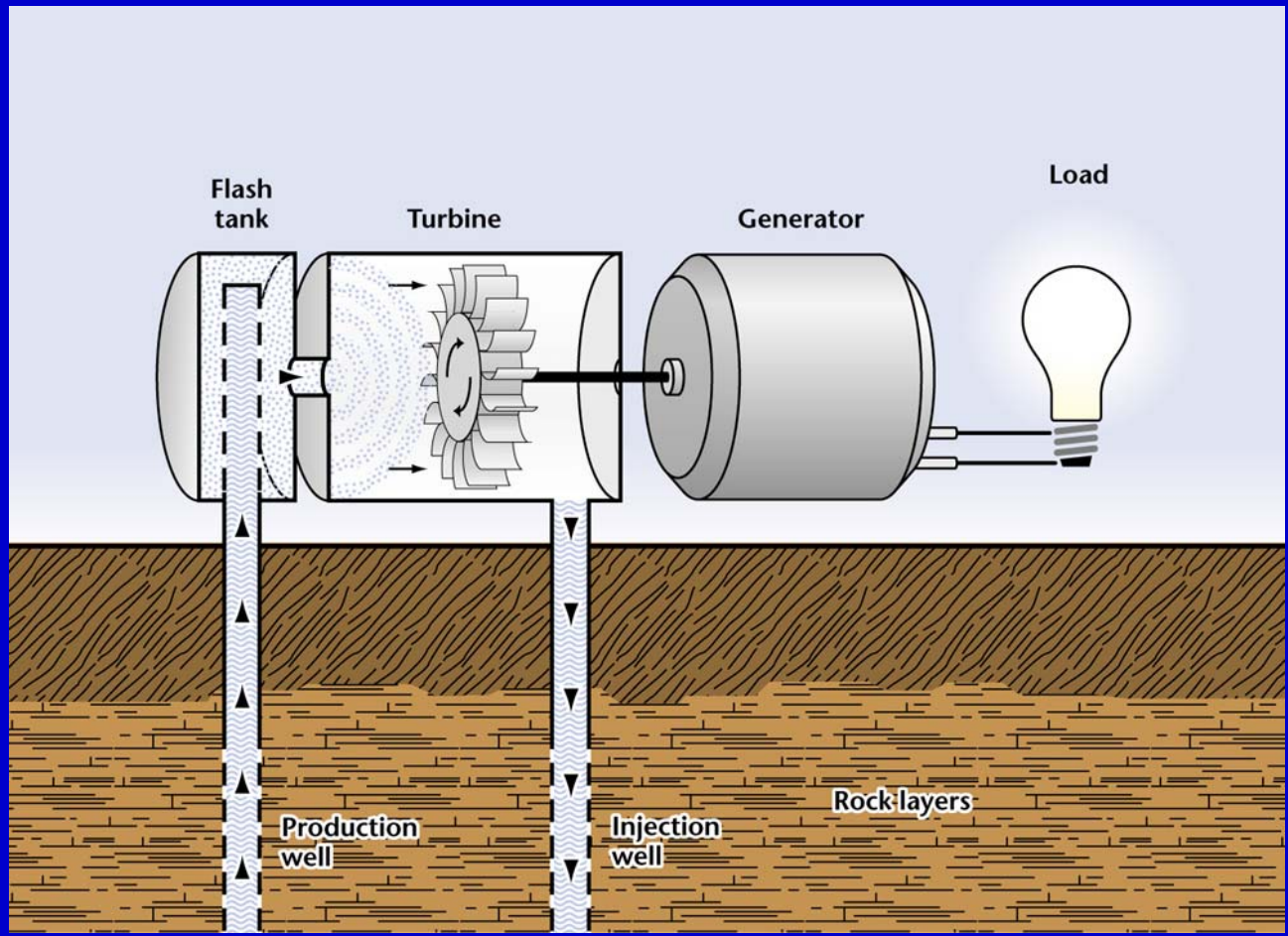
Geothermal power plants produce almost 5% of California's electricity (12.8 million MWh in 1999)

This hybrid binary/flash power plant provides about 25% of electricity demand on the Big Island of Hawaii

Plant Type vs. Temperature



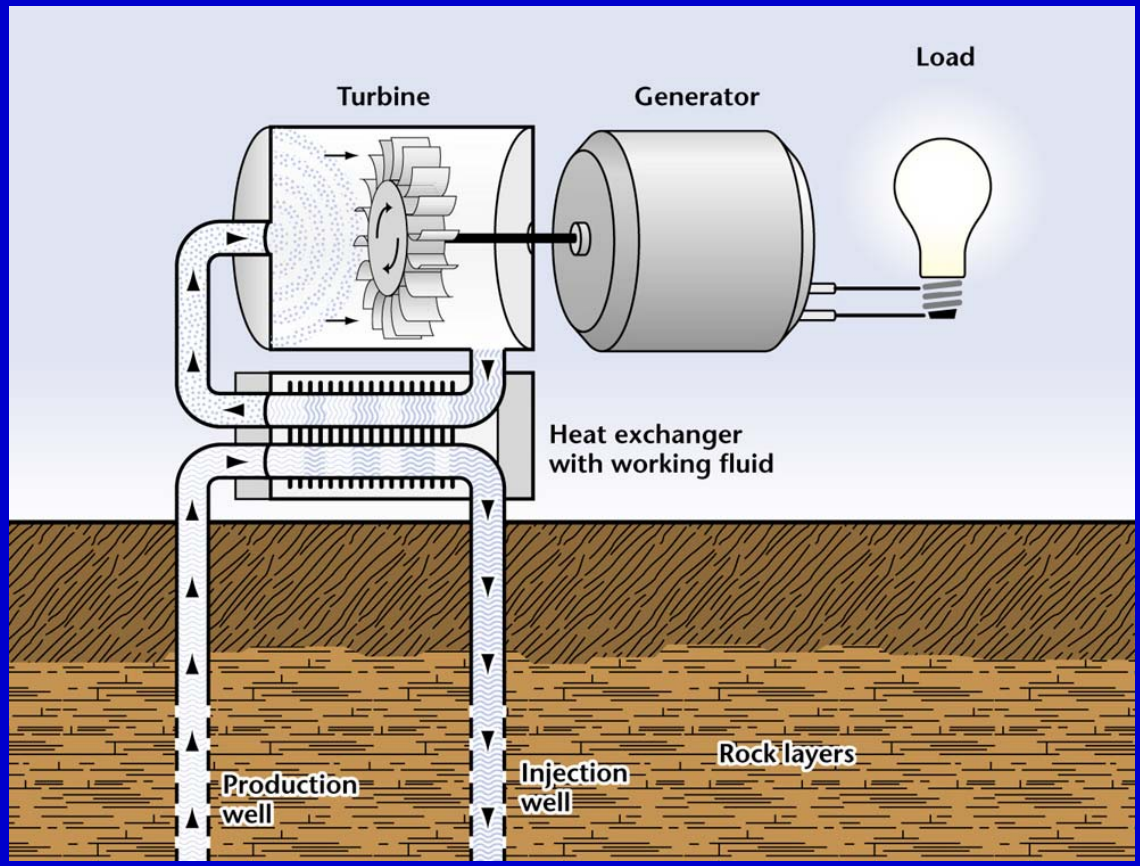
Flash Steam Power Plant



NREL

As this hot water flows up through wells some of the hot water boils into steam. The steam is then separated from the water and used to power a turbine/generator. Leftover water and condensed steam are injected back into the reservoir.

The Geysers, near San Francisco. The largest geothermal field in the world – has successfully produced power since the early 1960s.



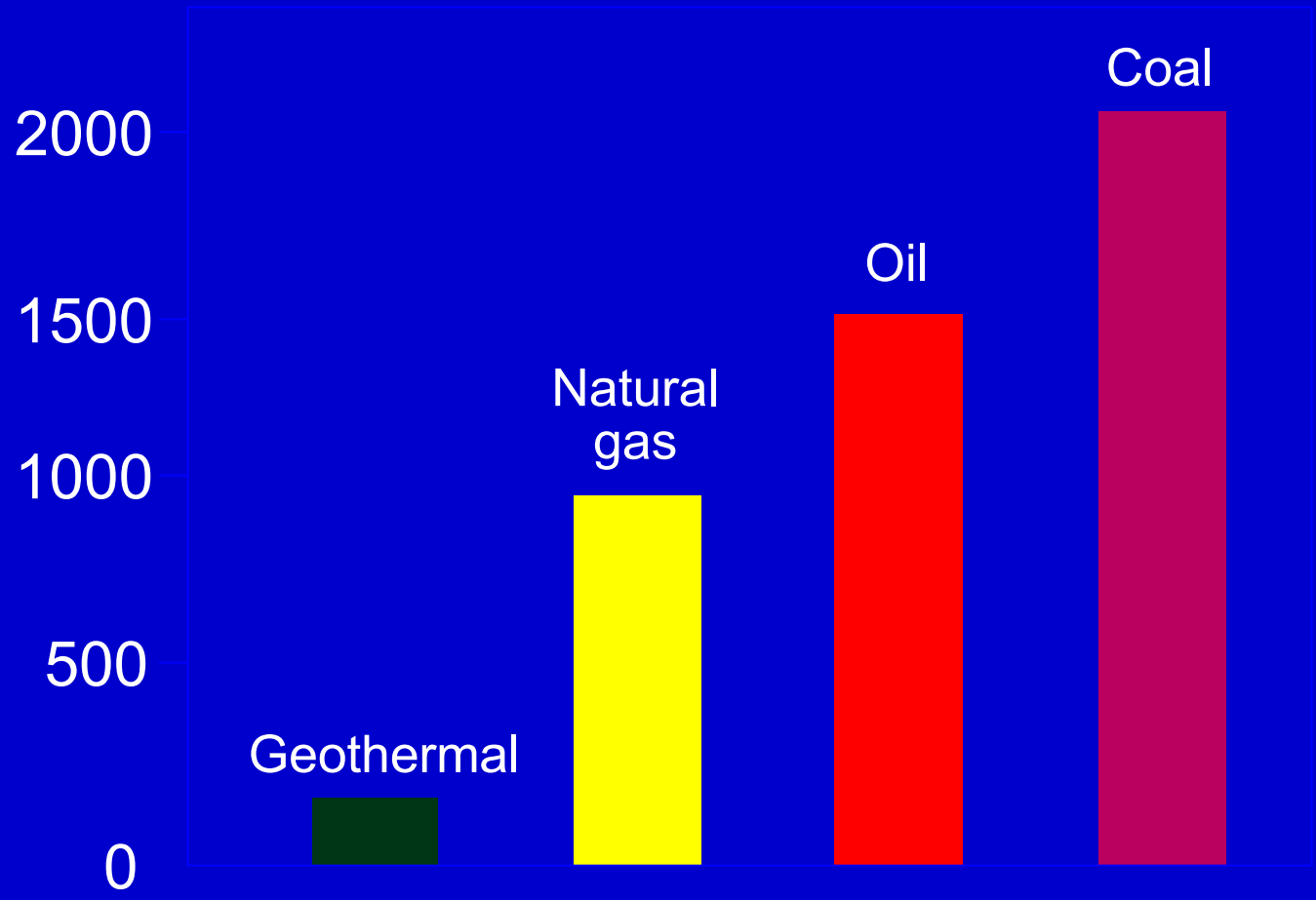
NREL

Operates on water at lower temperatures of about 225°– 350°F (107°–175°C). These plants use the heat from the hot water to boil a *working fluid,* usually an organic compound with a low boiling point. The working fluid is vaporized in a *heat exchanger* and used to turn a turbine. The water and the working fluid are kept separated during the whole process, so there are little or no air emissions.

The Mammoth geothermal plant -- Located in the eastern Sierra Nevada mountain range in California, showcases the environmentally friendly nature of geothermal power. Three air-cooled binary units generate a total of 28 megawatts of electricity, and release essentially no emissions into the atmosphere or land surface.

Imperial Valley, California. The drilling of production wells, such as this one in southern California, results in one-third to one-half of the cost of a geothermal project.

CO_2 Emissions Comparison
(lbs/MW-hr)

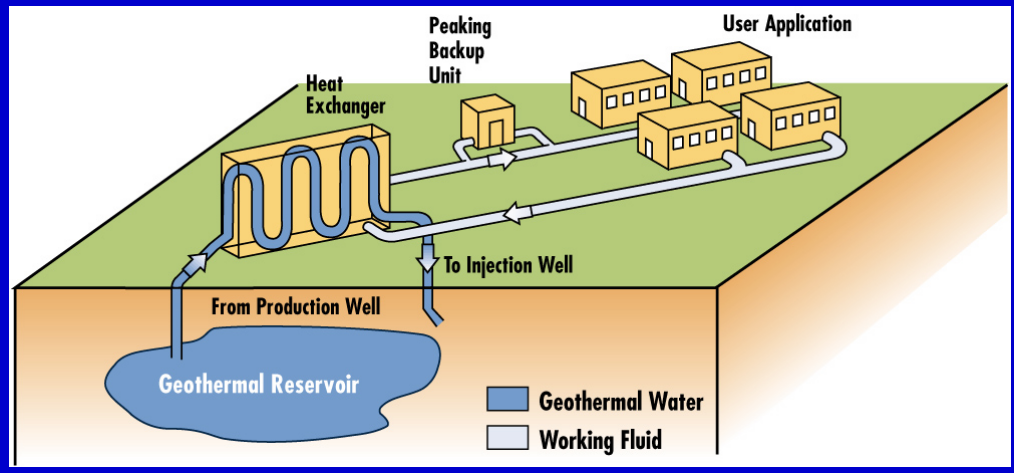


Source EIA 1998; Bloomfield and Moore 1999

Direct Uses

- Agriculture (greenhouse and soil warming)
- Aquaculture (fish, prawn, and alligator farming)
- Industrial Uses (product drying and warming)
- Residential and District Heating
- Balneology (hot spring and spa bathing)

Direct Uses



District Heating

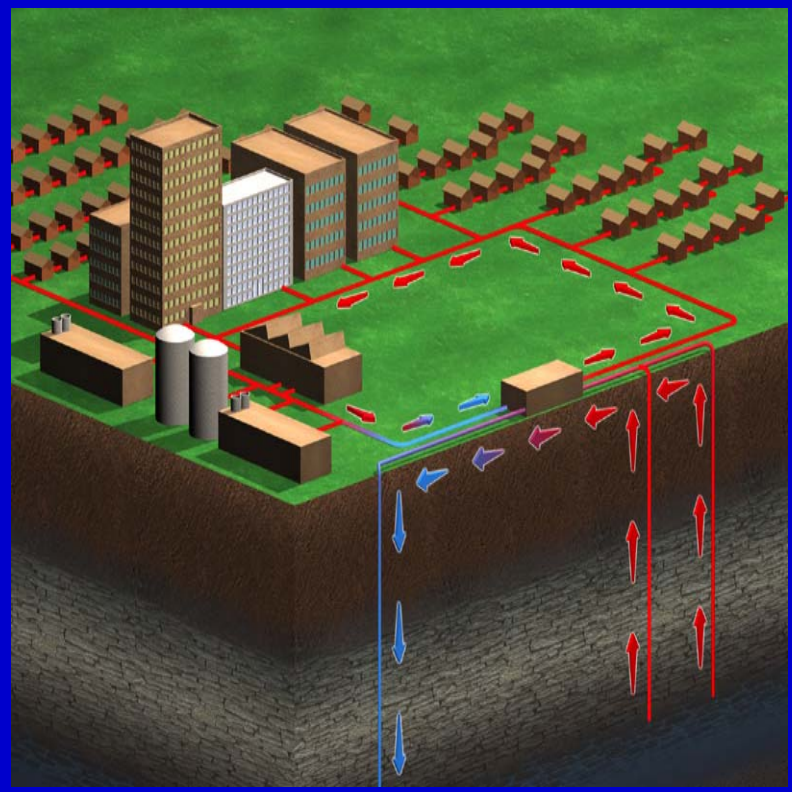
Greenhouses

Space Heating

Snow Melting

District Heating in Western U.S.

- There are 18 district heating systems operating in the western United States.
- Over 270 cities in the western U.S. are close enough to geothermal reservoirs to use district heating.



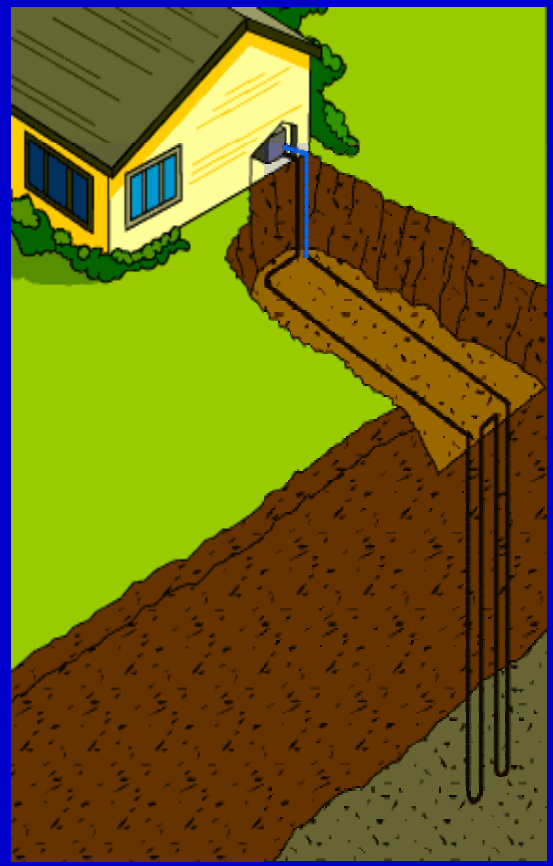
District Heating in Western U.S.

The Idaho State Capital Building (Boise) uses geothermal energy.

The Ada County Courthouse (Boise) uses the city geothermal district-heating system.

Geothermal Heat Pumps

Heating Mode



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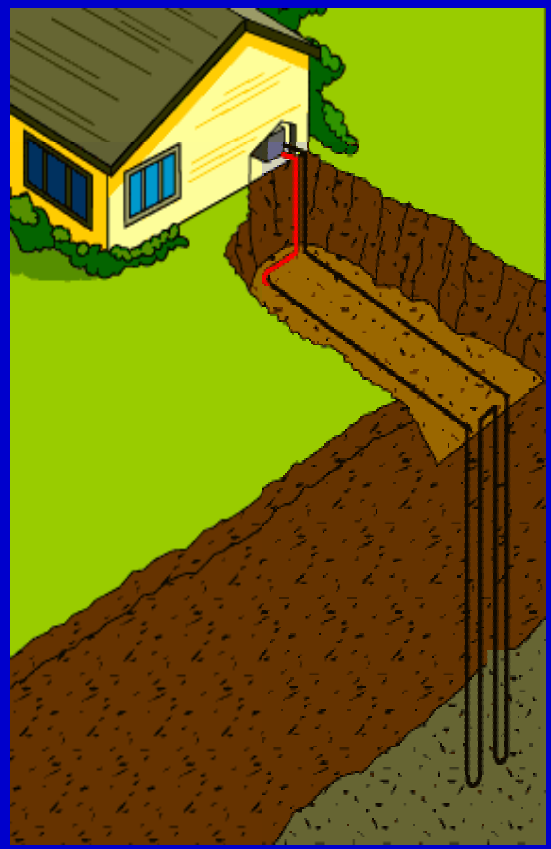
Geothermal heat pumps use the stable temperatures of the ground (often vertical boreholes typically are 100 to 400 feet deep) as a heat source to warm buildings in winter and as a heat sink to cool them in summer. Also called ground-source heat pumps or Geoexchange units.

Geothermal Heat Pumps

Cooling Mode



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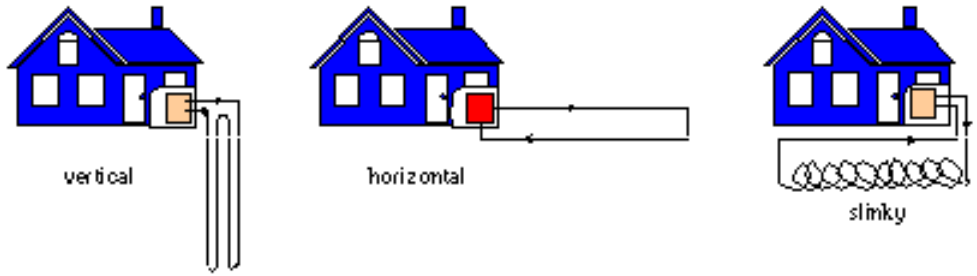
GEOTHERMAL HEAT PUMPS (GHP)

a.k.a. Ground Source Heat Pumps (GSHP)

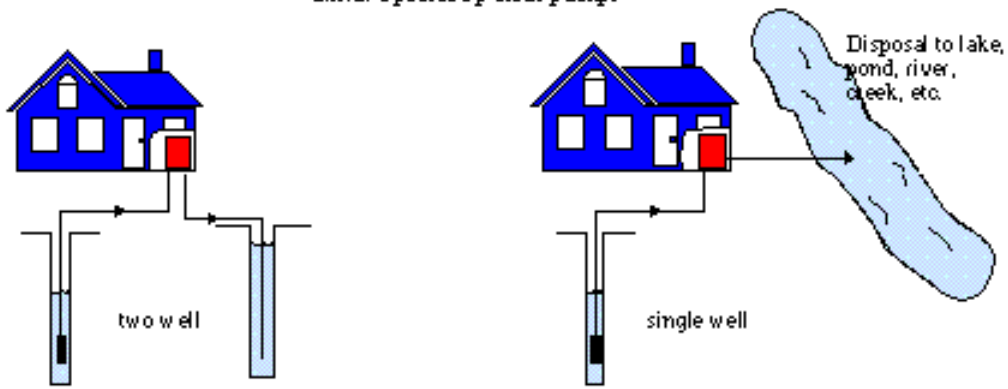
Ground Coupled Heat Pumps (GCHP)

a.k.a. closed loop heat pumps



Groundwater Heat Pumps (GWHP)

a.k.a. open loop heat pumps



Surface Water Heat Pumps (SWHP)

a.k.a. lake or pond loop heat pumps

Geo-Heat Center

Residential application in Colorado – a happy homeowner.

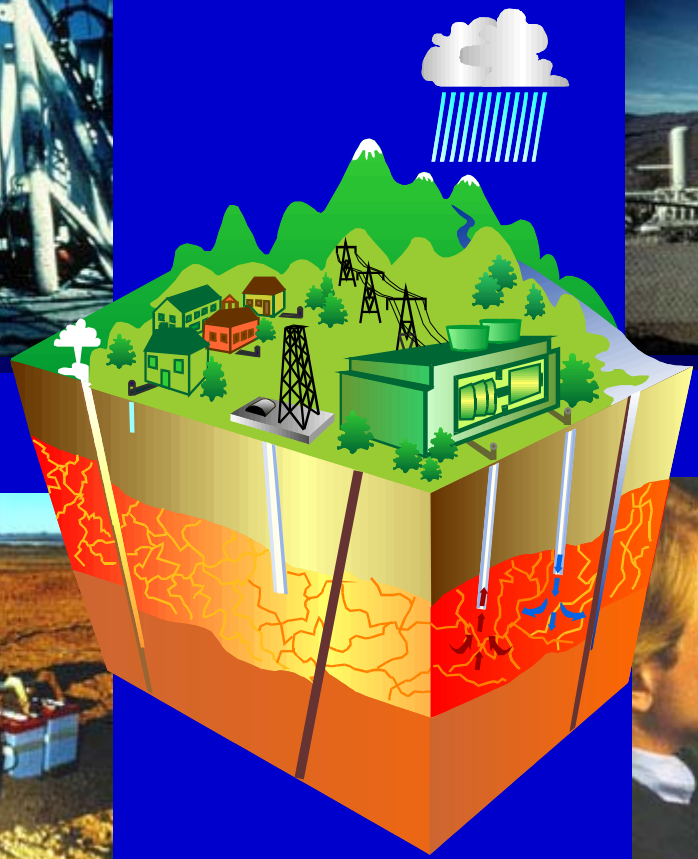
Commercial application in Idaho showing two 36-ton units.

Summary of Geothermal Energy Use in the U.S.

- 2,200 megawatts of electricity supplying 4 million people in western U.S. and Hawaii
- 650 thermal megawatts of direct use for heating and cooling
- 3,700 thermal megawatts geothermal heat pumps, about 750,000 in use today.

Developing Geothermal Technology

Drilling



Energy Conversion

Exploration

Reservoir Technology

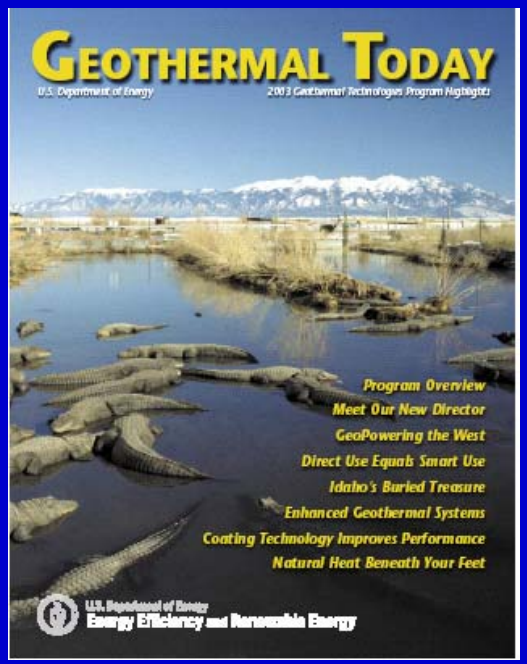
DOE Role

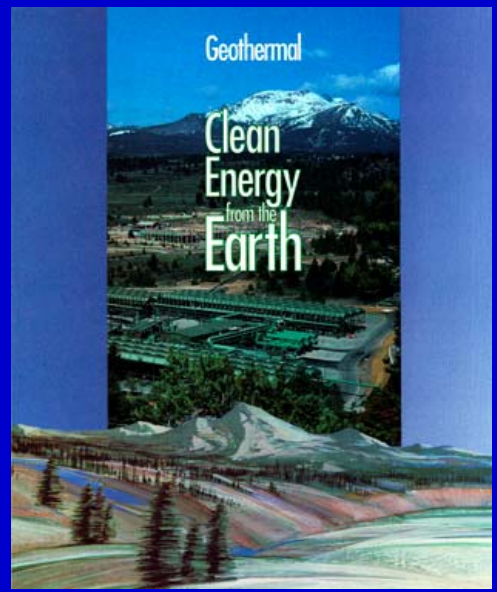
- R&D and deployment activities to enable expanded geothermal energy use
- Support technical assistance and replicable field verification projects
- Outreach and removal of barriers are important activities: GeoPowering the West

Sources of Information and Technical Assistance*

- General; Department of Energy, Geothermal Technologies Program* www.eere.energy.gov/geothermal
- Direct Use; GeoHeat Center, Oregon Institute of Technology* www.geoheat.oit.edu
- General Information; Geothermal Education Office www.geothermal.marin.org/
- National Labs* e.g. www.nrel.gov, www.inel.gov, www.sandia.gov.
- Geothermal Heat Pump Consortium, www.geoexchange.org

Geothermal Energy Outreach Materials and Activities





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