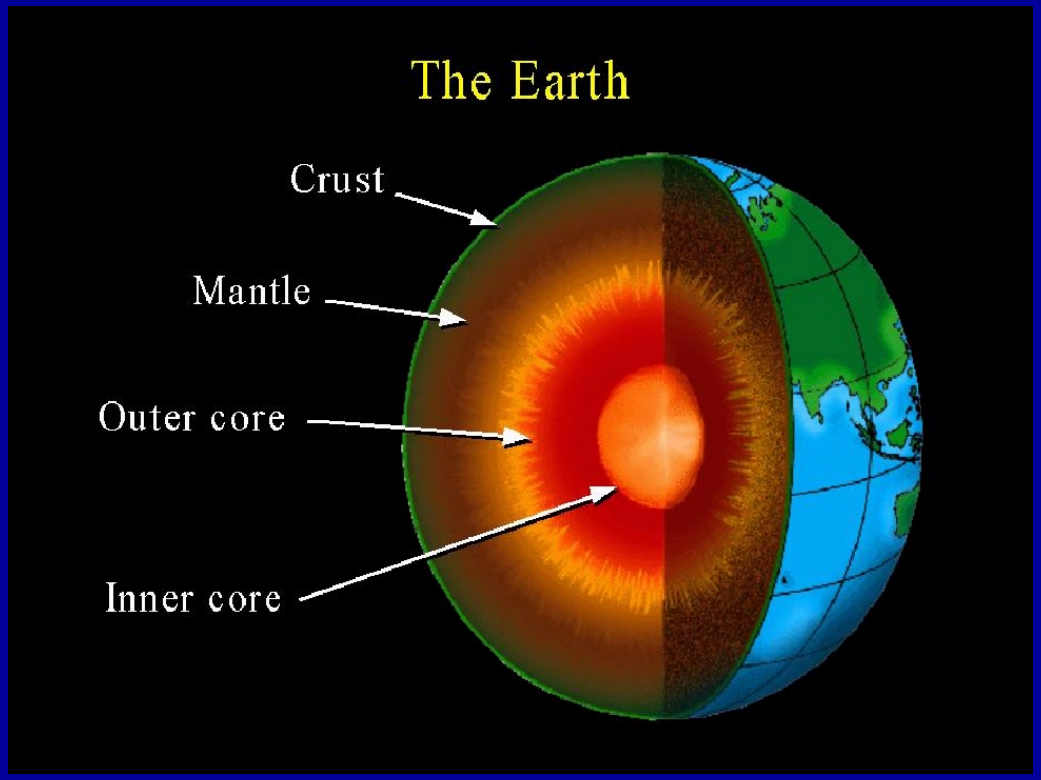
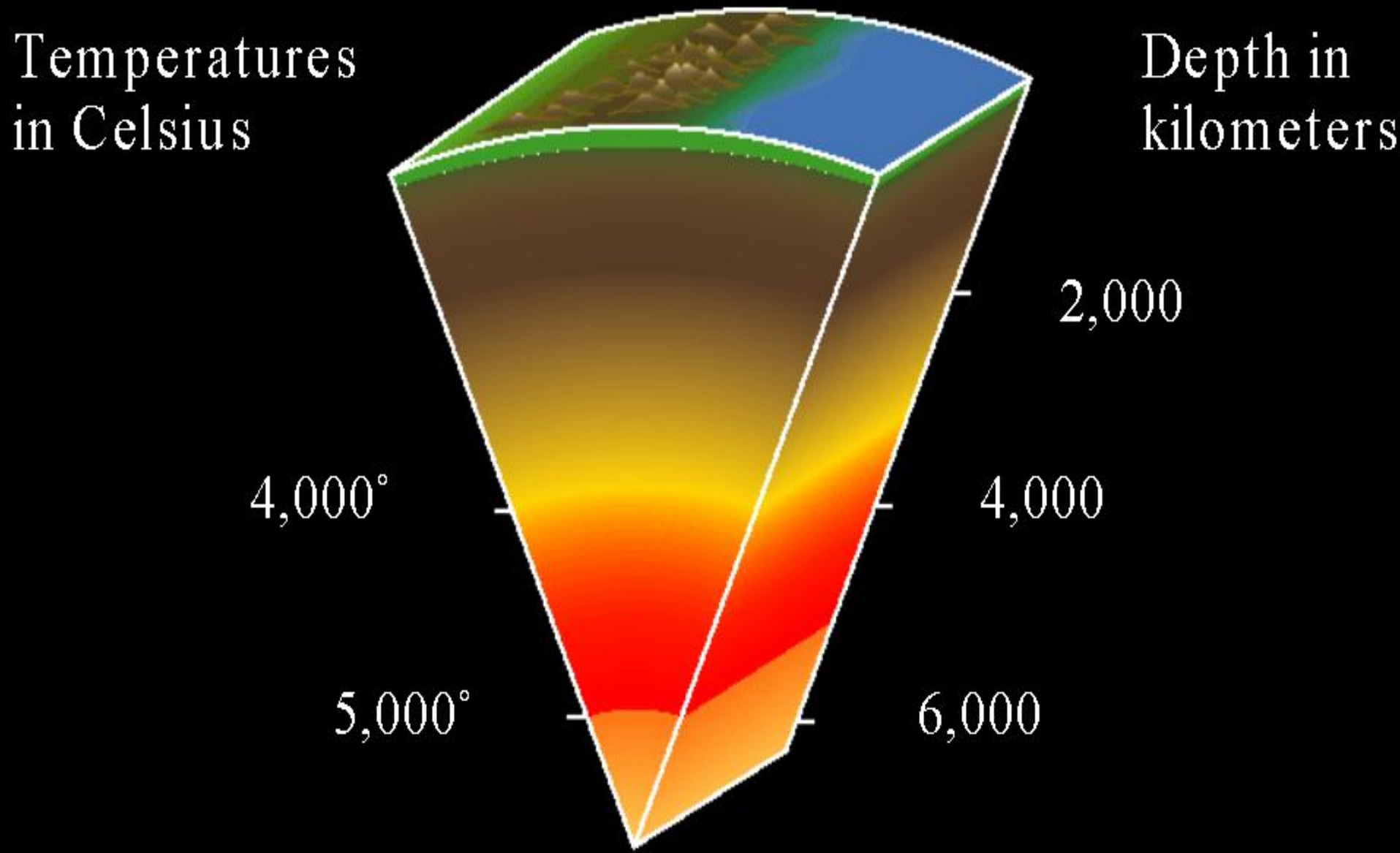
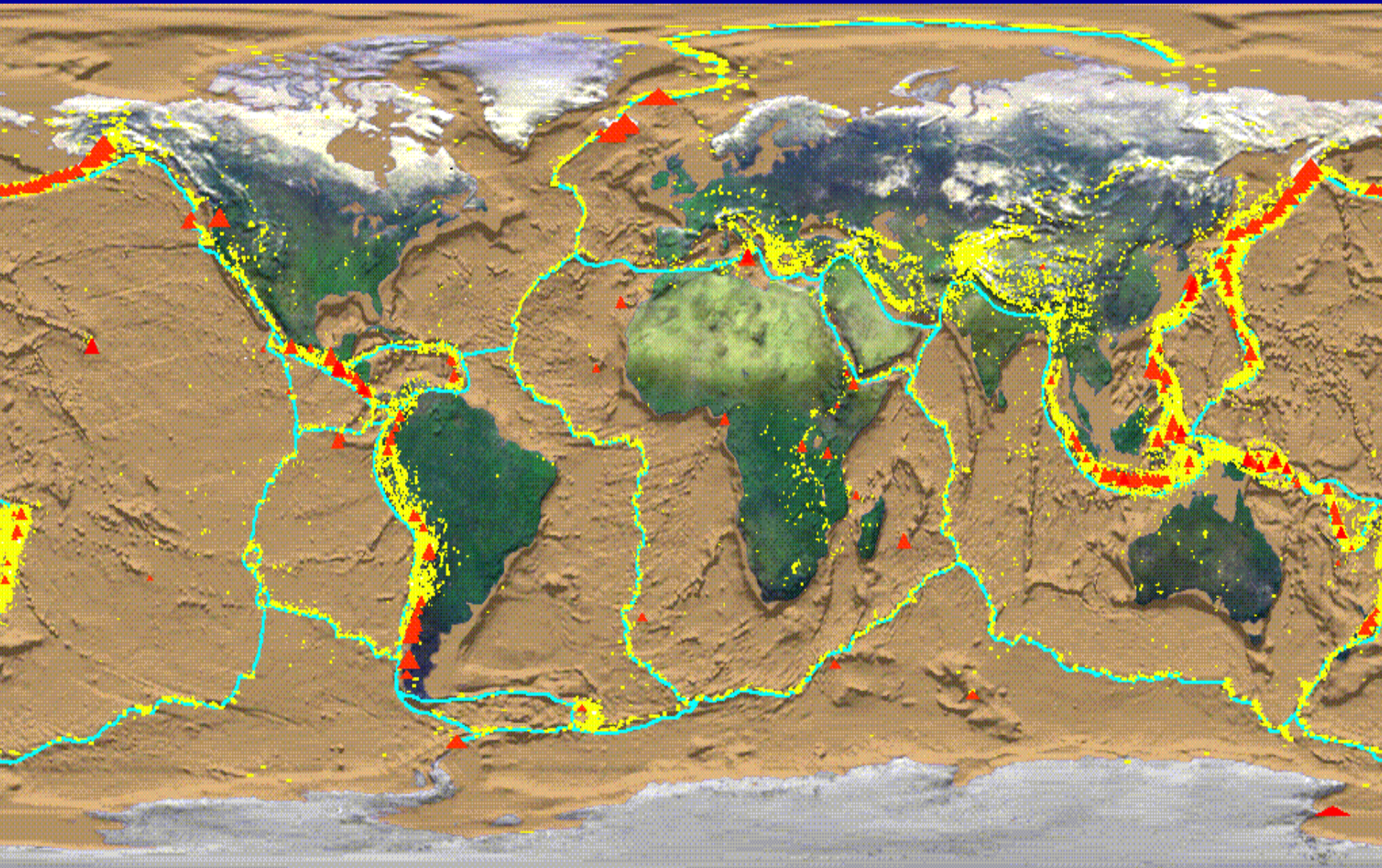
Geothermal Energy – Beneficial Uses of Heat from the Earth

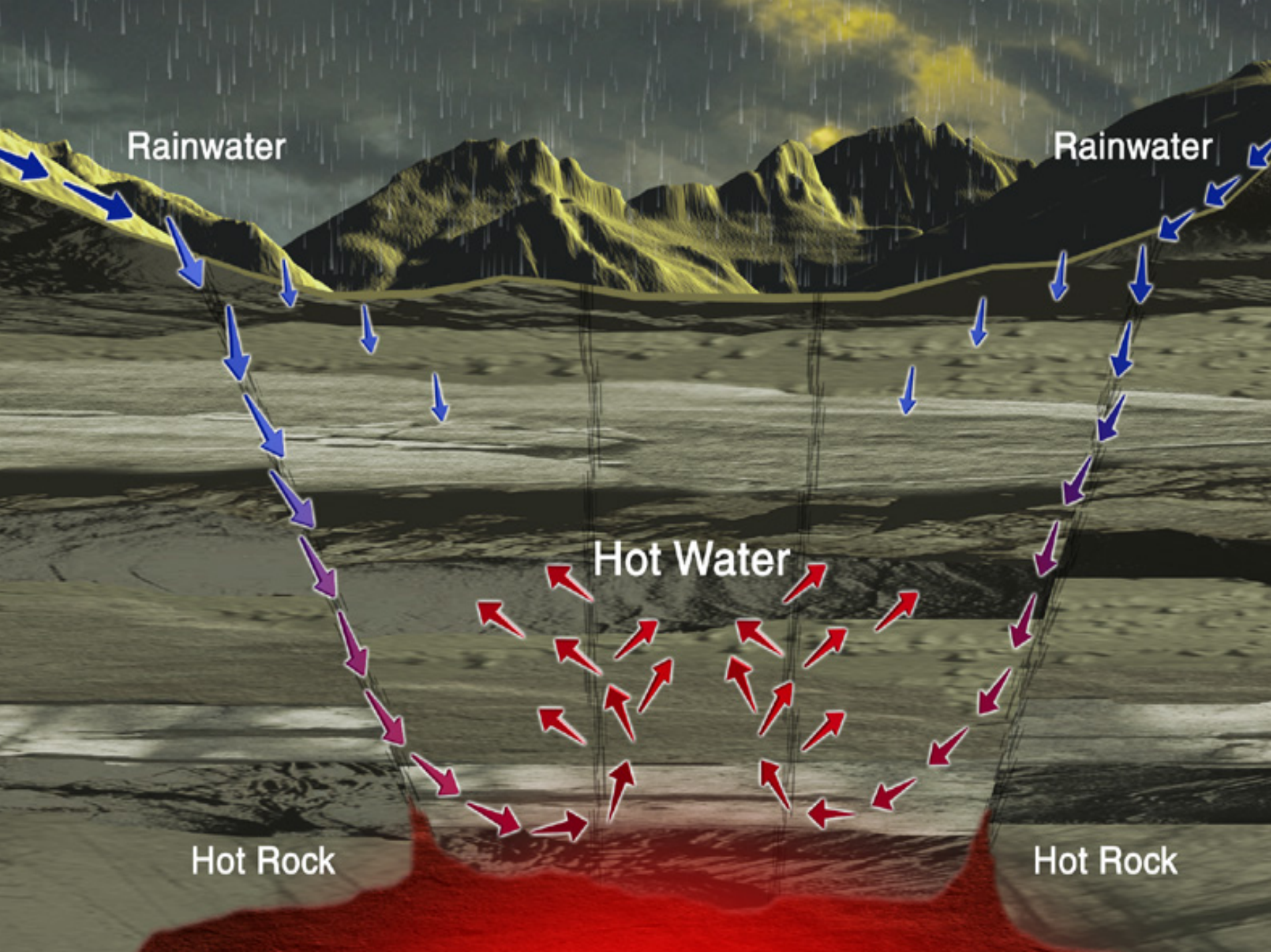


Temperatures in the Earth



Tectonic Plate Boundaries



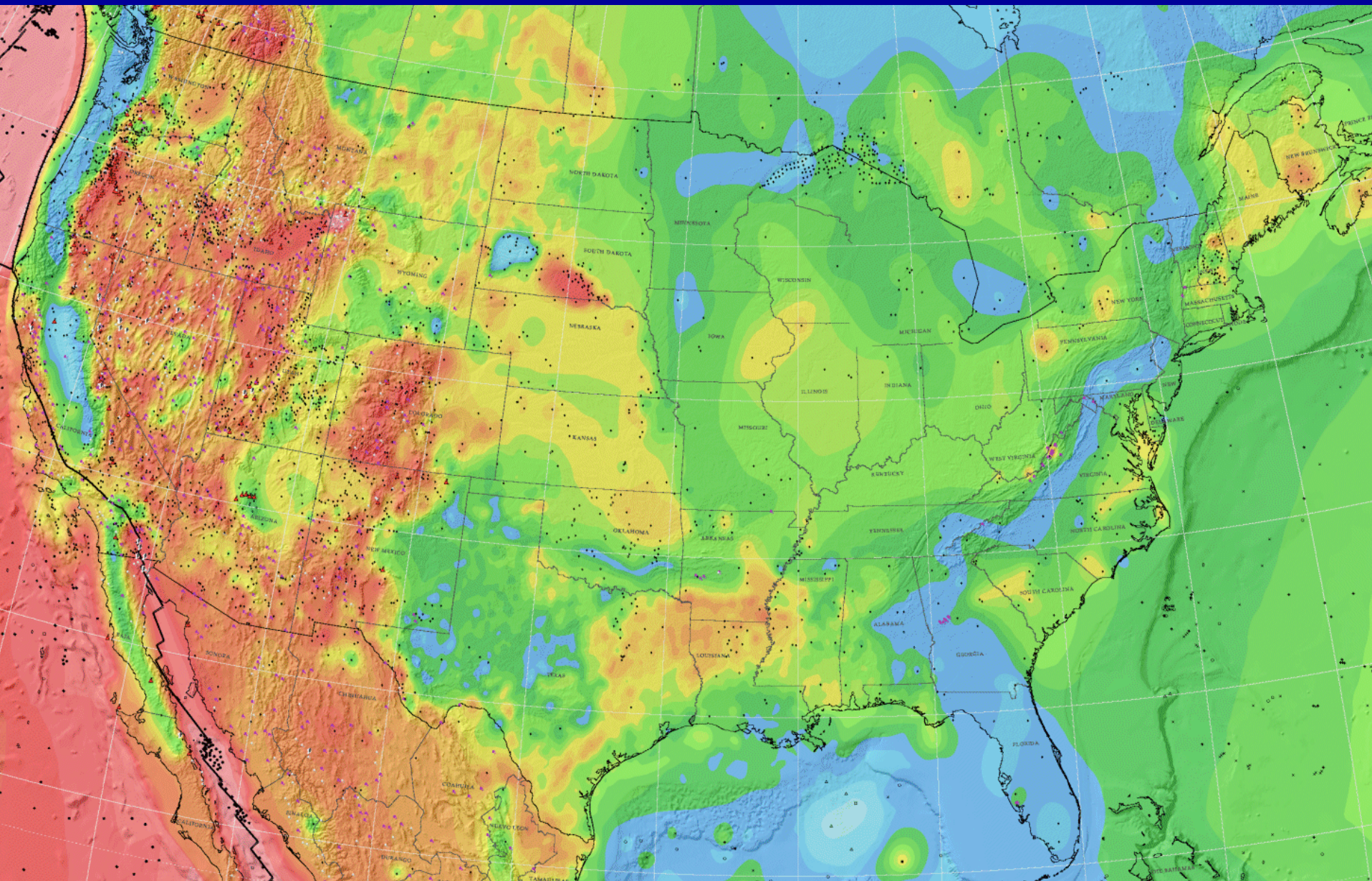

Rainwater
Rainwater
Hot Water
Hot Rock
Hot Rock

Introduction

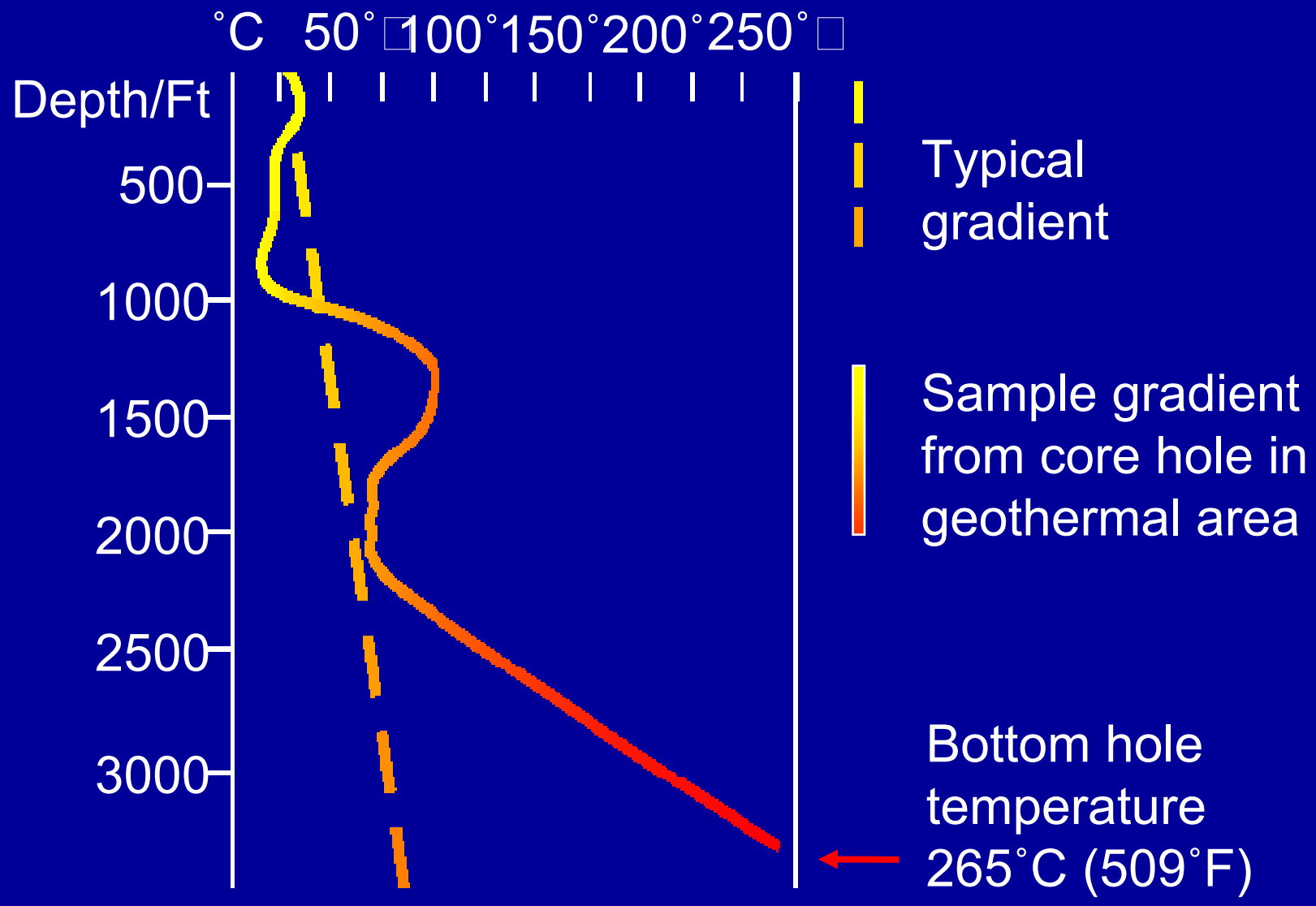
- **Four types of Geothermal Resources**
  - **Hydrothermal – our discussion today**
  - **Geo-pressured**
  - **Hot Dry Rock**
  - **Magma**

- **Greater than 120° C (250ºF) - produce electricity**
- **Greater than 40°C (105ºF) - direct thermal use**
- **Everywhere, can use geothermal heat pumps (GHPs) for heating and cooling.**

Geothermal Resource Potential

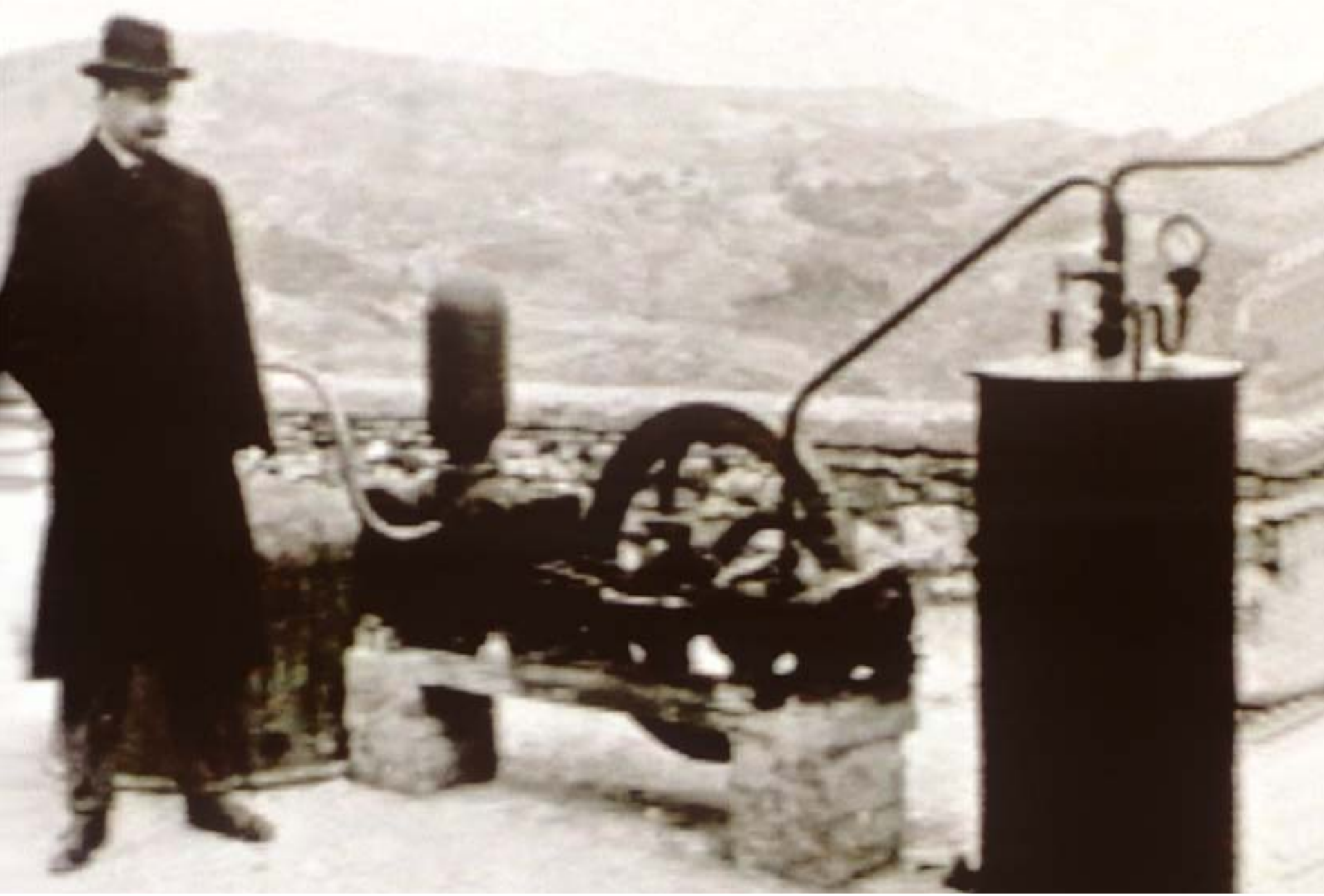


Sample Temperature Gradient Data



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

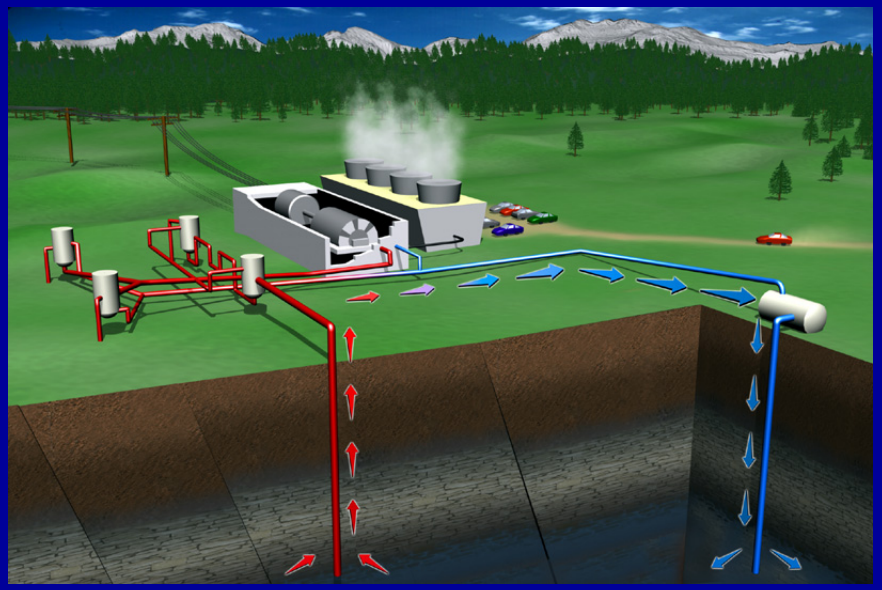


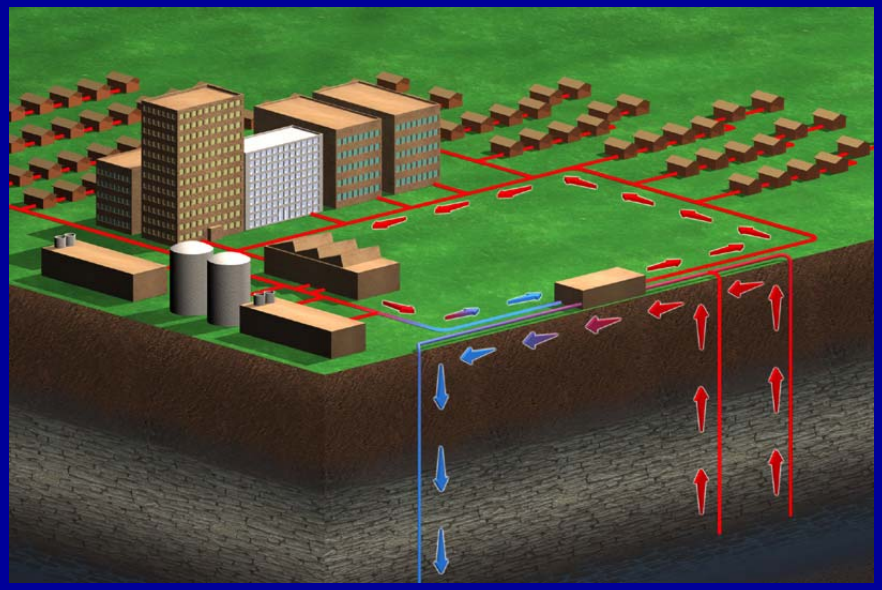
First Geothermal Power Plant, 1904, Larderello, Italy

Advantages of Geothermal Electricity

- Large and widespread resource
- Both supply- and demand-side applications
- Environmentally sound
- Virtually inexhaustible with good management practices
- High plant availability (>95%)
- Steady base-load power
- Relatively low cost (~4 – 8 cents/kWh)
- Worldwide market

Geothermal Energy Technologies – Using the Earth's Heat





Electricity Generation

- Distributed Power
- Central Station Power

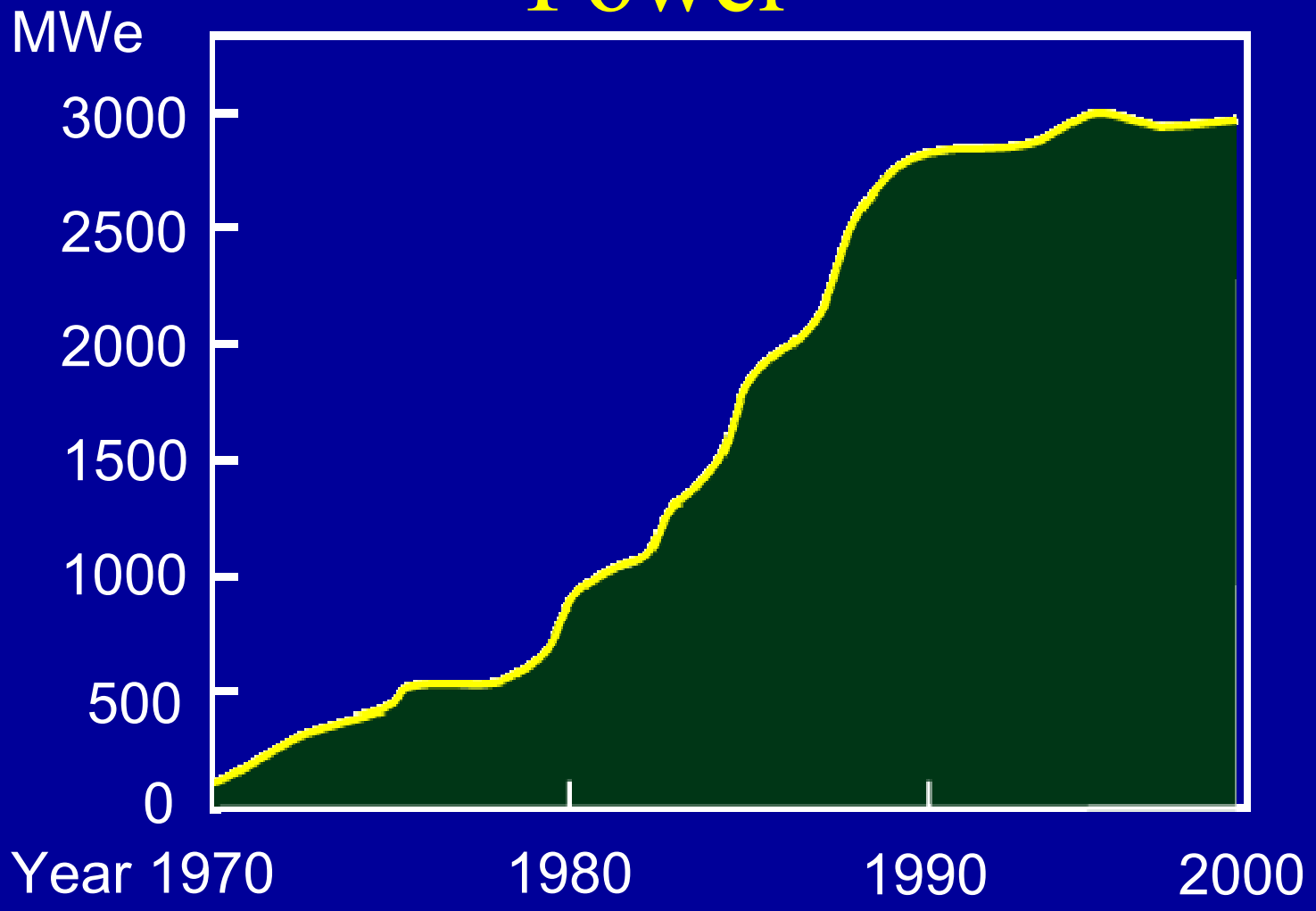
Heat Production

- District Heating
- Process Heat
- Agriculture
- Aquaculture

Today's Plants

- 8,000 MWe being generated in 21 countries
- 22 plants in U.S. (mostly California and Nevada) providing 2,200 MWe
- Hydrothermal resources could provide additional 20,000 MWe in U.S., 75,000 MWe in developing nations

Growth in U.S. Geothermal Power



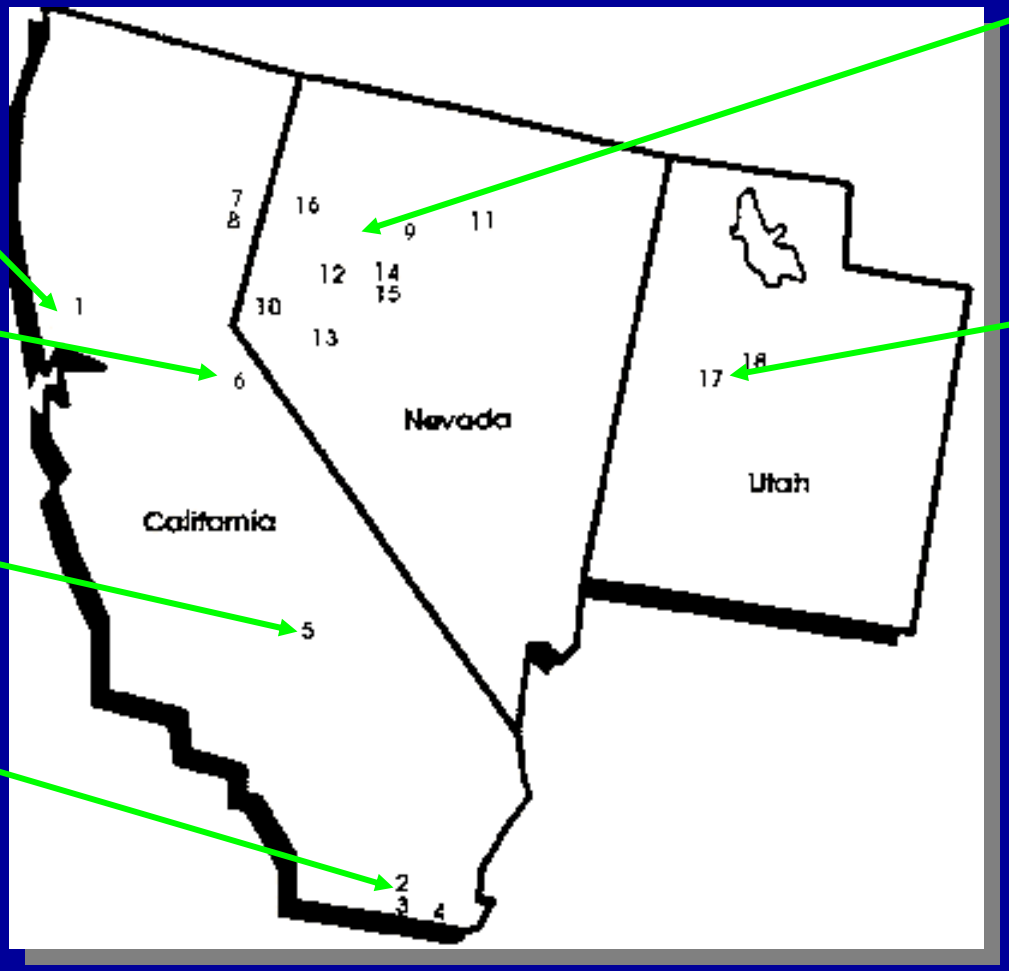
Current U.S. Geothermal Power Production

Geysers
2070 MW

Mammoth
40 MW

COSO
240 MW

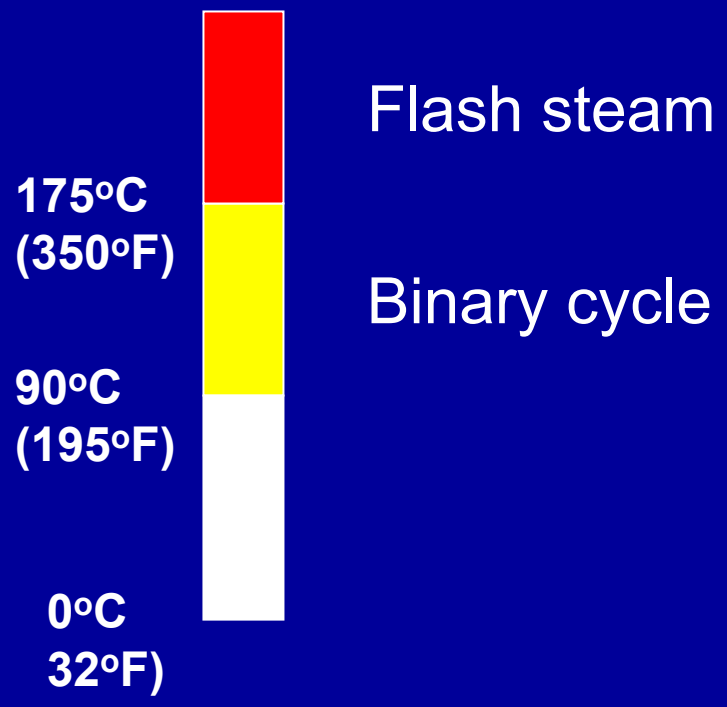
Imperial
Valley
403 MW



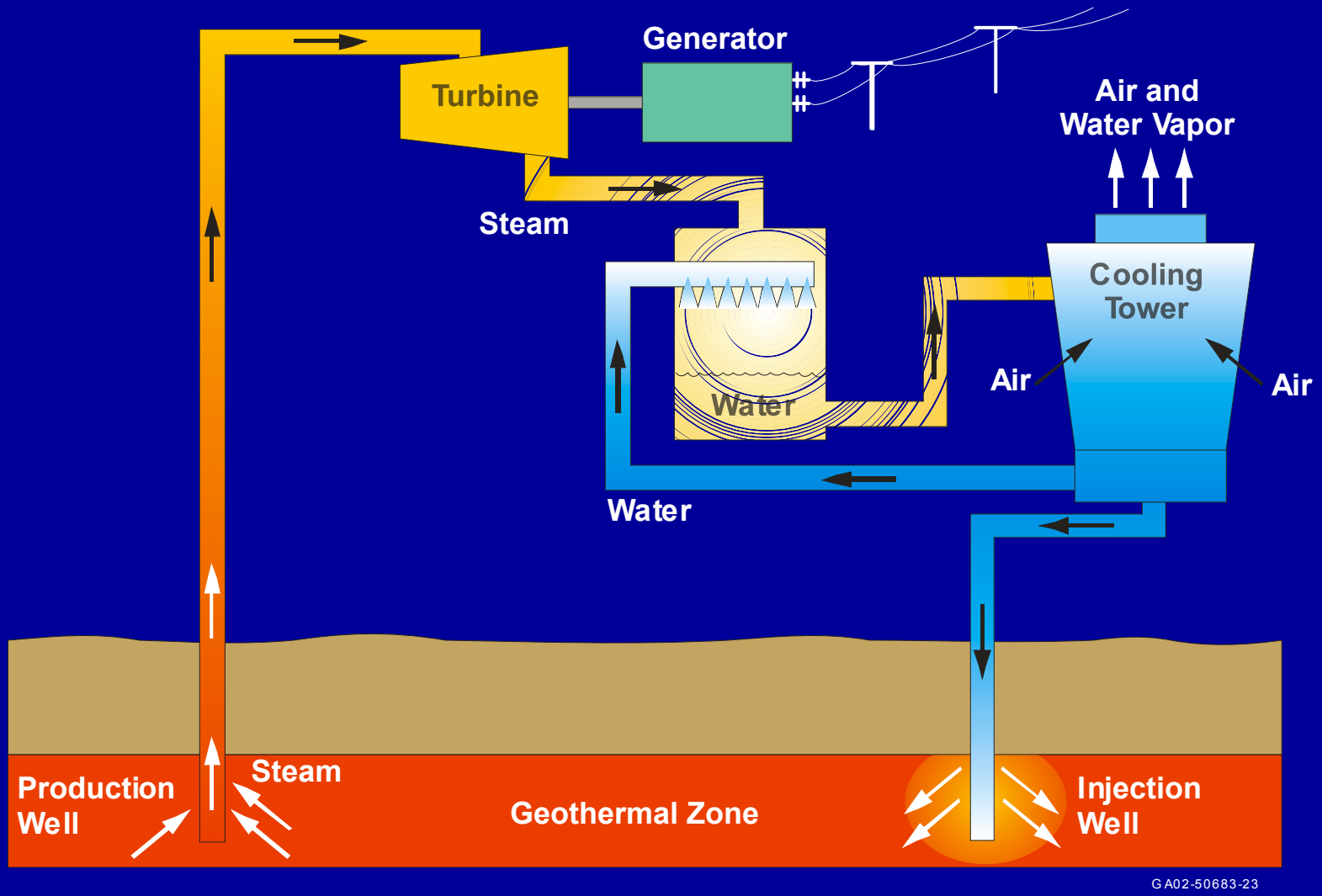
Nevada
Production
196 MW

Utah
Production
33 MW

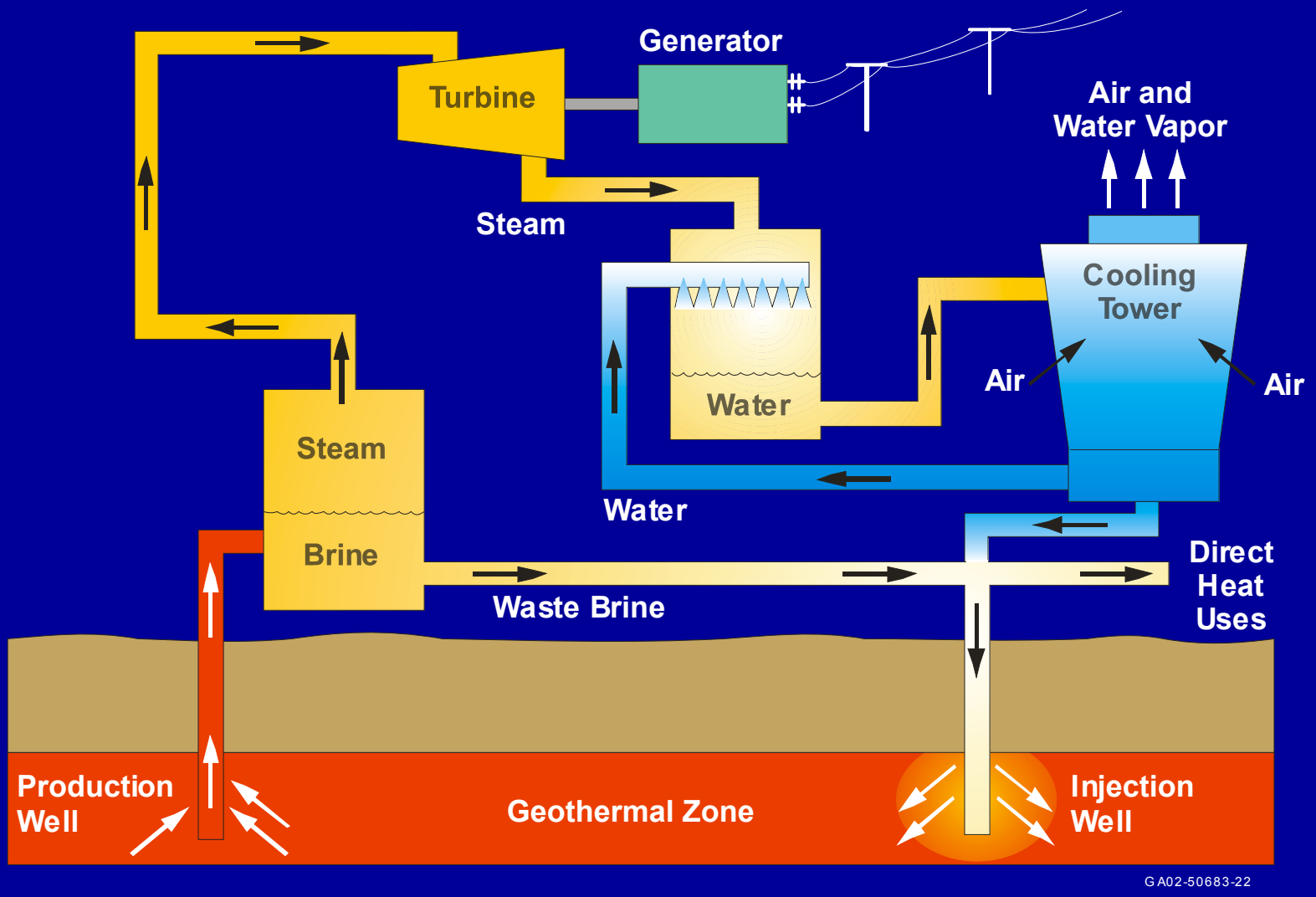
Plant Type vs. Temperature



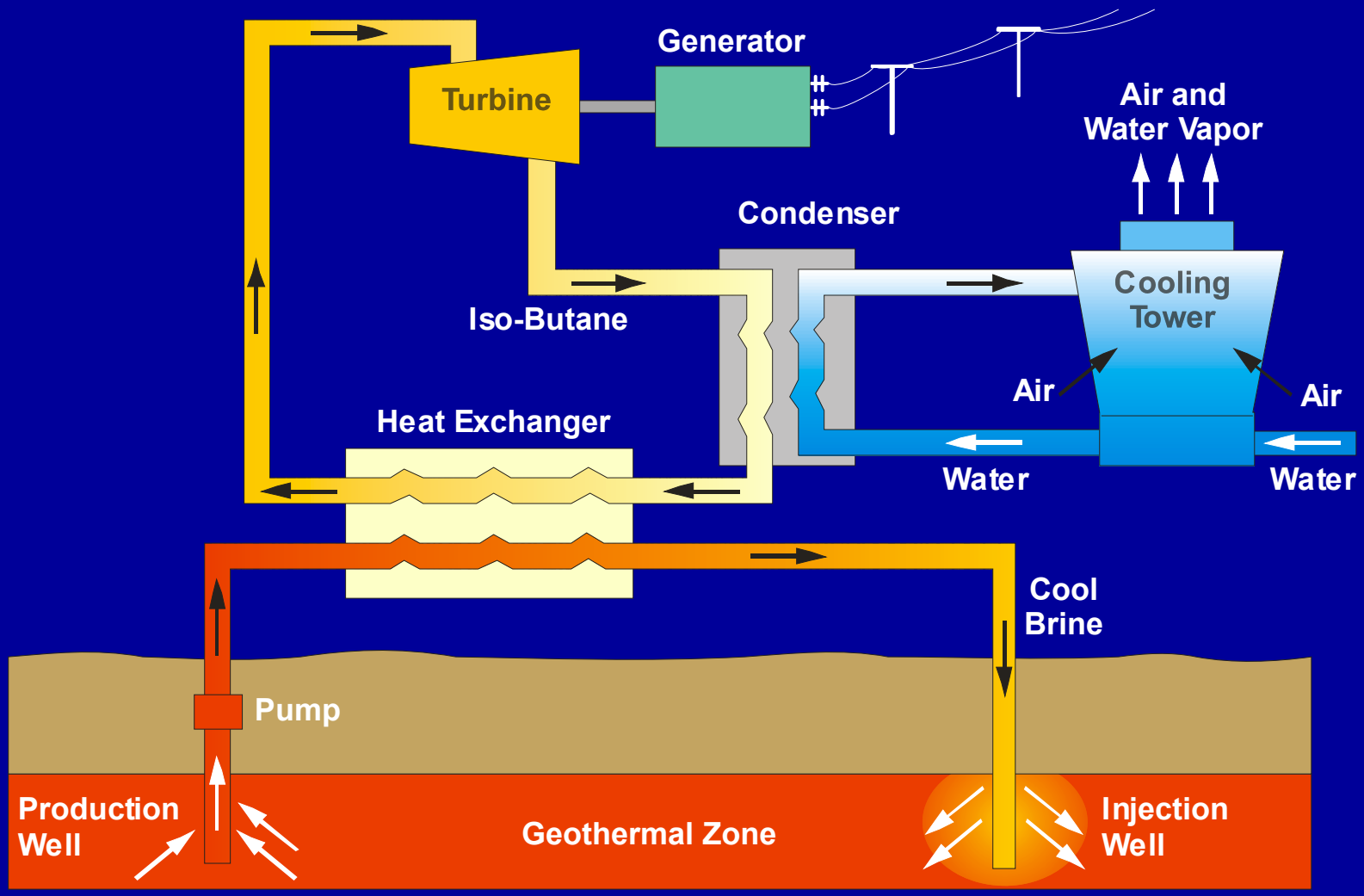
Dry Steam Power Plant



Flash Steam Power Plant



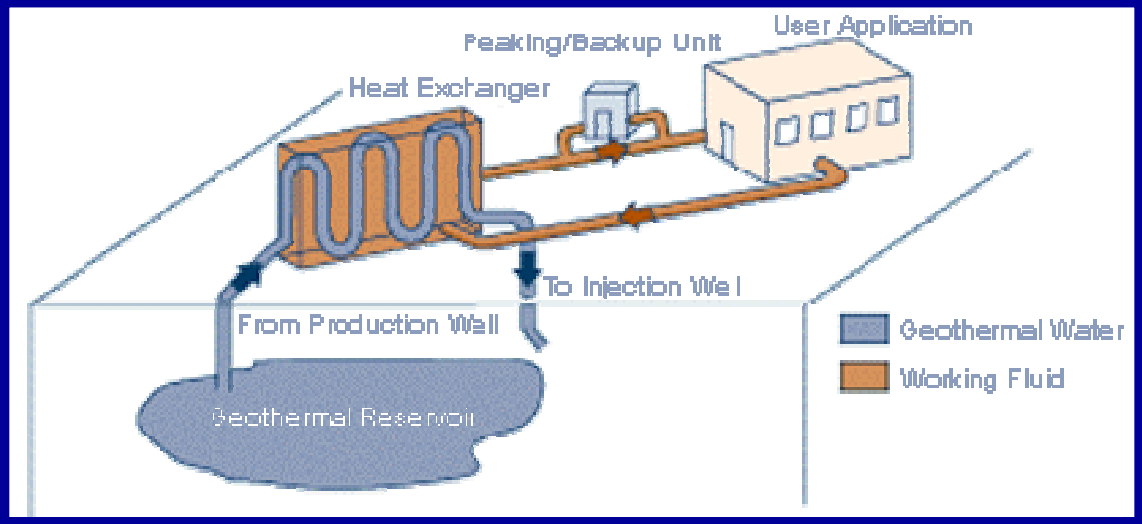
Binary Cycle Power Plant



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.

Plant Costs

Direct Use of Geothermal Energy



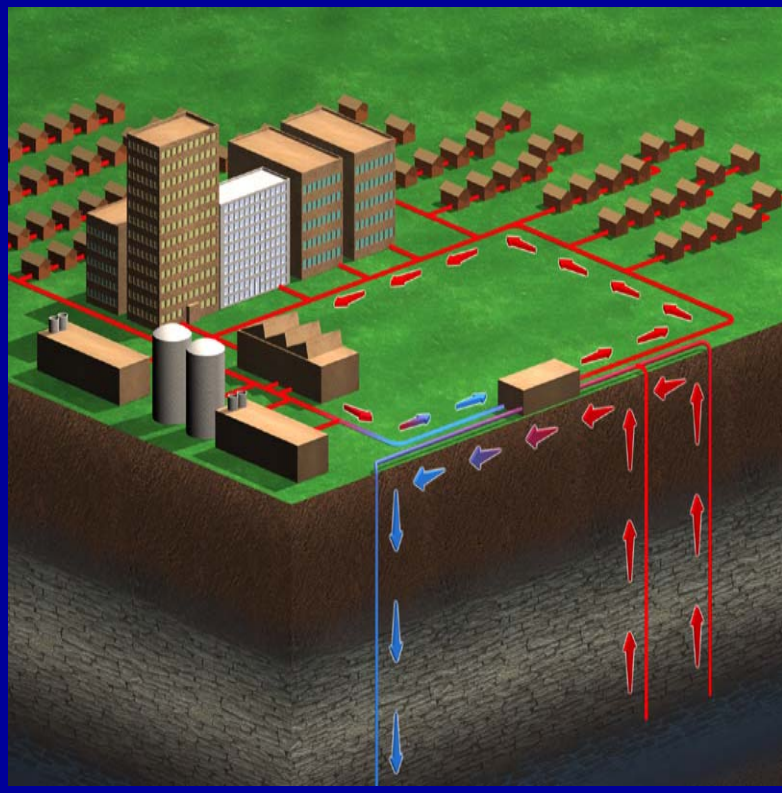
Greenhouses

Space Heating

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.**



Direct Uses

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

Geothermal Energy For Heat and Power

Domestic Benefits

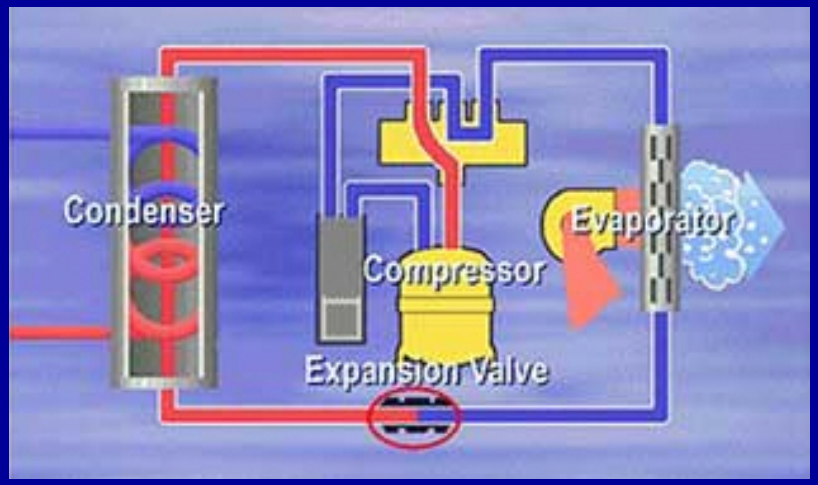
- $2.0 billion domestic annual energy sales
- Baseline power – 90%+ capacity factor
- 6% of California electricity generation, 10% northern Nevada, 25% island of Hawaii
- Over $600 million in cumulative royalties to Federal government
- Four million customers served annually

Global Market

- Over 8,000 MW of electric capacity in 21 countries
- Over 11,000 MW of thermal capacity in 40 countries
- Serves 60 million people annually

How a Geothermal Heat Pump (GHP) Works

- It's **like a refrigerator** – it's cold in the box and warm at the coils
- At a certain depth, ~6 ft, **the ground is at a near constant temperature, year around.**
- Ground is warmer than the air in the winter and cooler than the air in the summer.



- **Winter**
  - –Extract heat from the ground and pump it into the house to warm it. House is the condenser in the refrigeration system at the right
- **Summer**
  - –Remove heat from the house (House is the evaporator in the refrigeration system at the right) to cool it and reject the heat to the cooler earth.
- **GHPs are like an appliance!**

Heat Pump in Winter

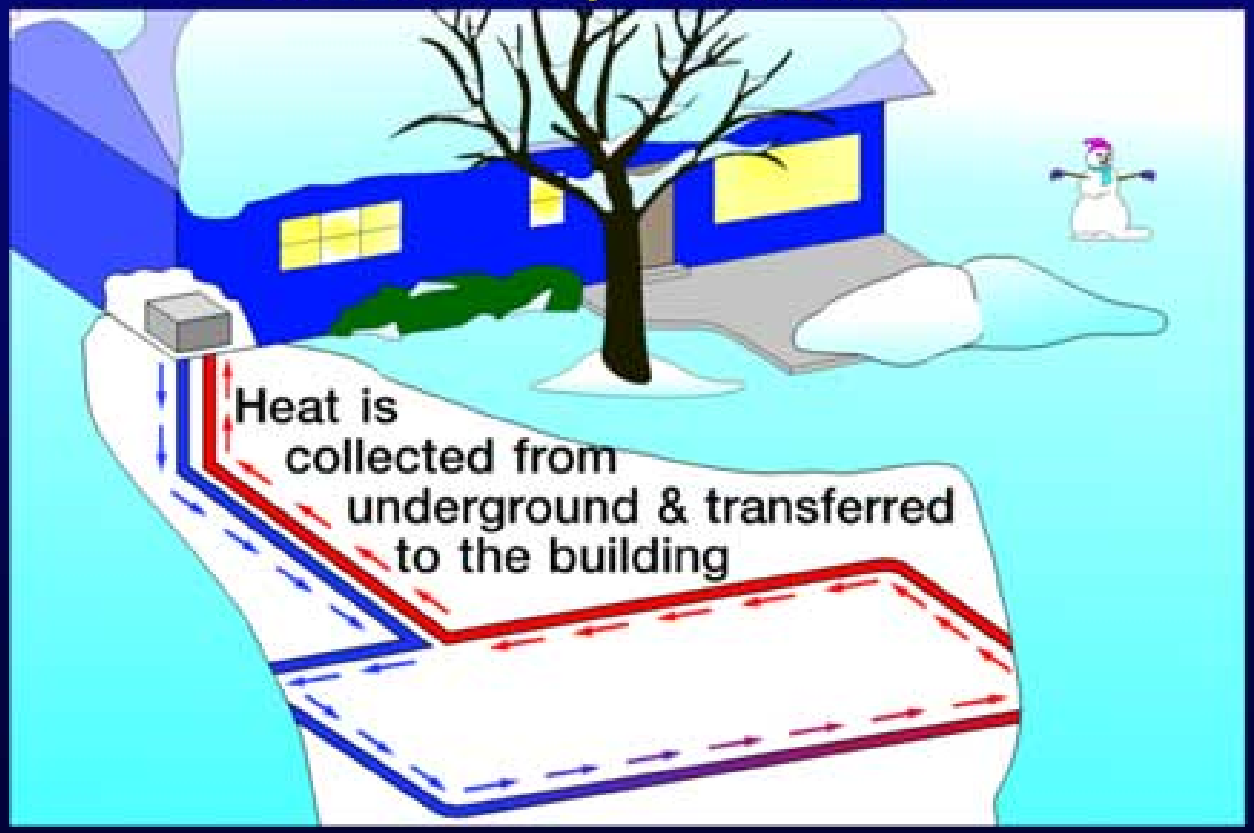


Diagram courtesy of the the Geothermal Education Office

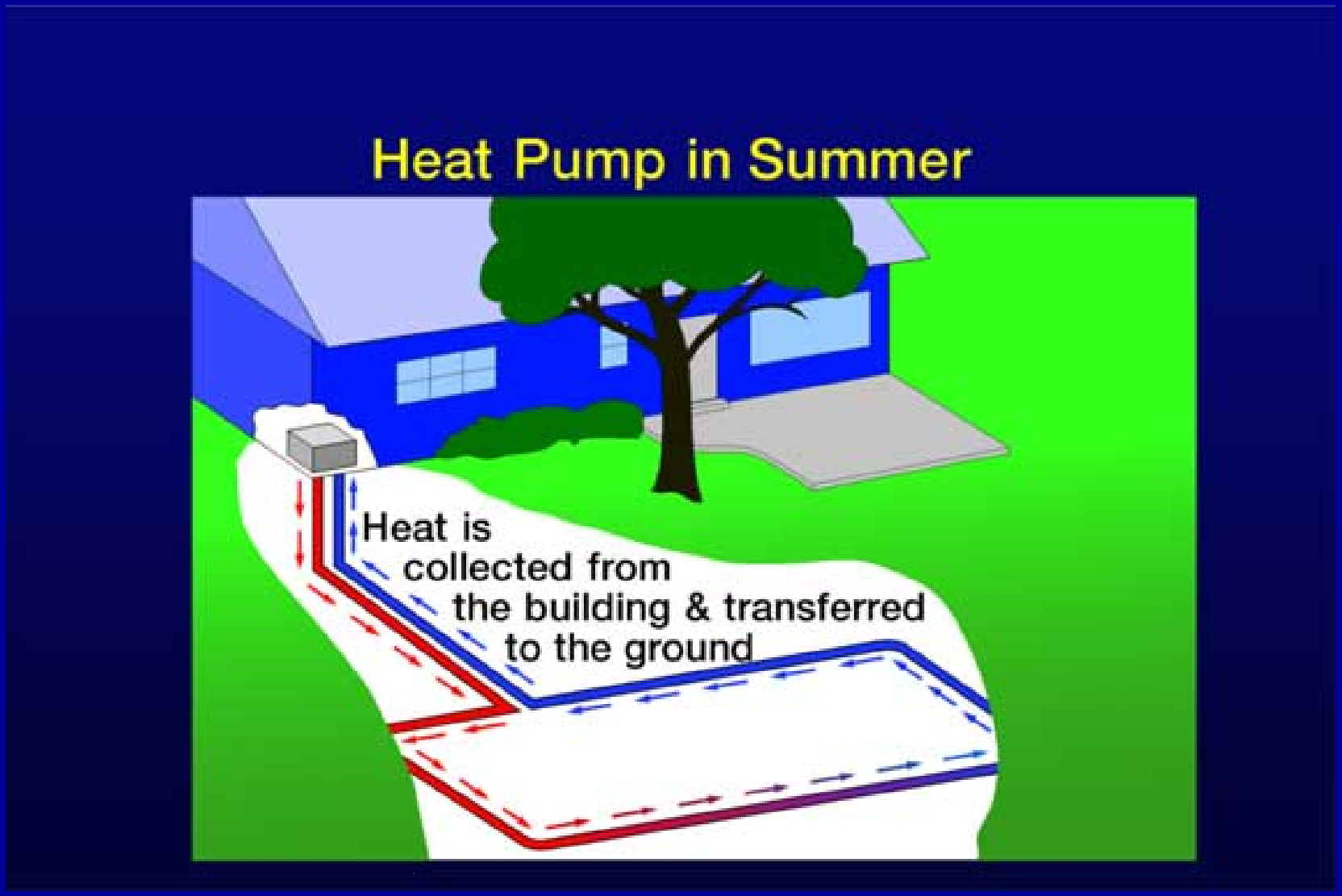


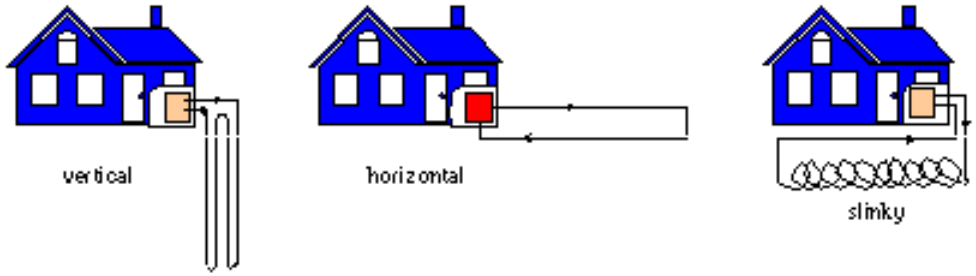
Diagram courtesy of the the Geothermal Education Office

GEOTHERMAL HEAT PUMPS (GHP)

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

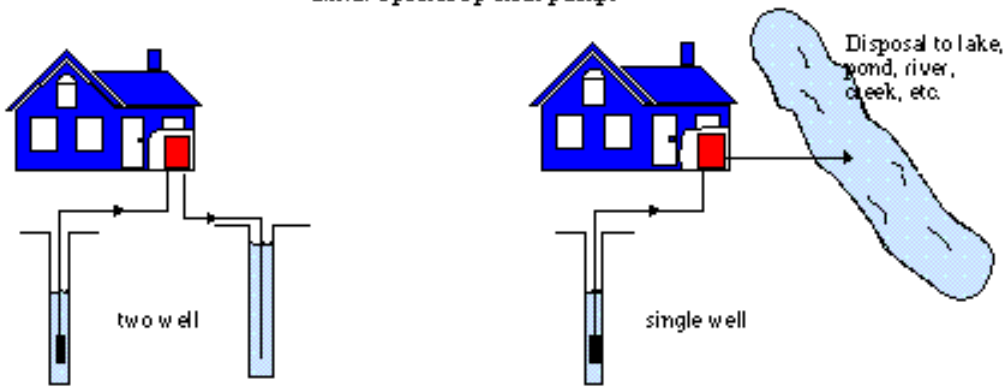
Ground Coupled Heat Pumps (GCHP)

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 Thermal Pond

Geo Thermal Pond

Geo Thermal Pond

Citizen Potawatomi, Oklahoma
FireLake Golf Course Club House

6 2:34 PM

6 2:35PM

WIDE LOAD

EXIT
ONLY
DIES

Well Drilling Rig

Geo Thermal Heat & Cooling Housing

Geothermal Heat Pump Characteristics "Using Mother Nature Effectively"

- Highly energy efficient
- High level of comfort
- Typically ~70% renewable energy
- Suitable for residential, commercial or industrial
- Typically 15-25 year life
- Environmentally beneficial with no combustion
- Higher first costs, but lower life cycle costs
- Multiple ways to install, with suitability for almost all geographic locations
- Proven technology

GHPs

- Very cost-effective for schools and community complexes
- Can cluster houses as a district heating system
- Will be even more cost advantageous as the price of fossil fuels continue to rise
- Many grants and incentives available.

Geothermal Summary

- Geothermal Energy can be used to generate base load electricity
- Direct thermal uses are widespread and cost-effective
- Geothermal heat pumps are very cost-competitive across the entire country
- Get professional assistance to ensure proper sizing and installation