

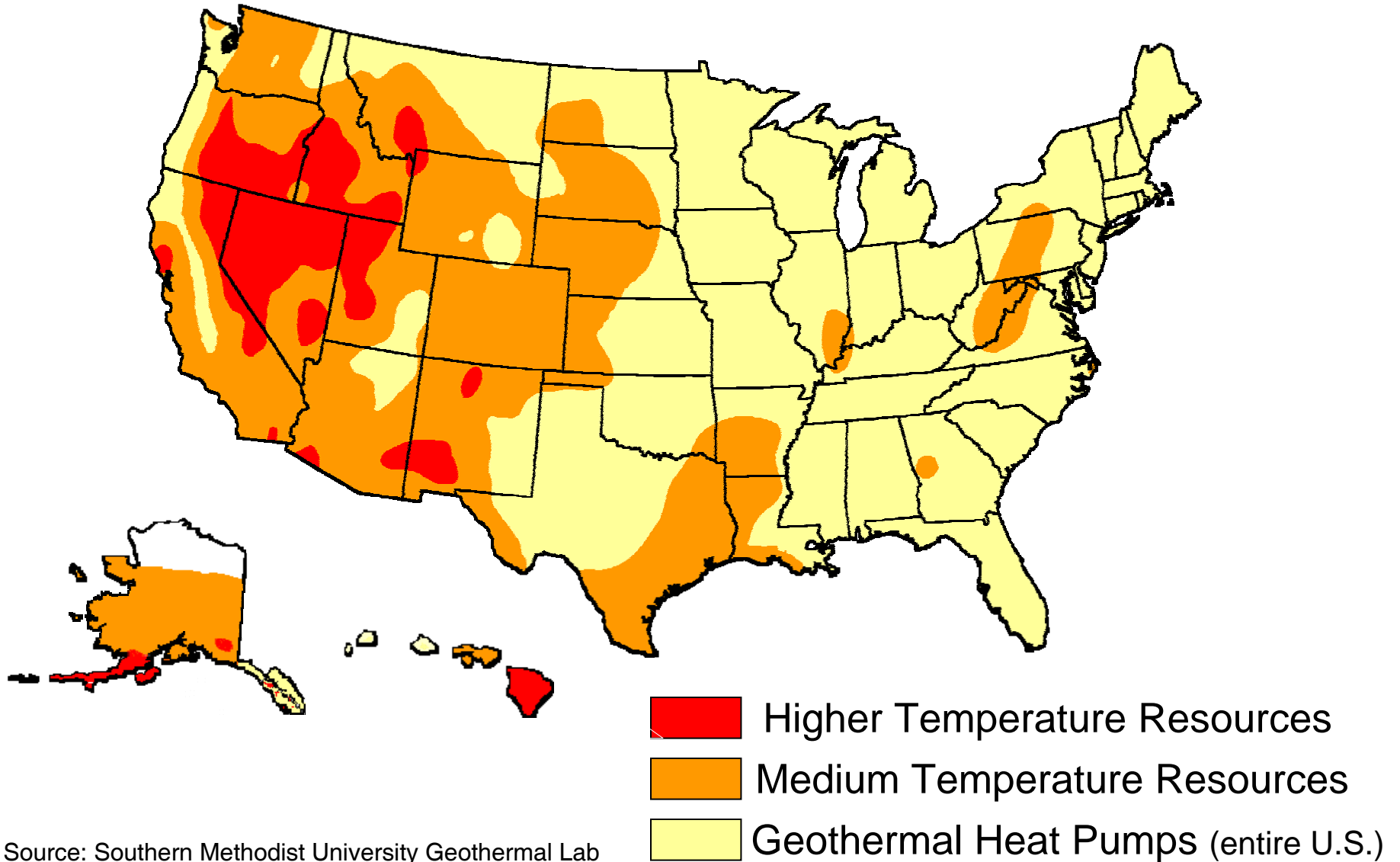
GEOHERMAL APPLICATIONS

The Role of Extension in Energy

June 30, 2009

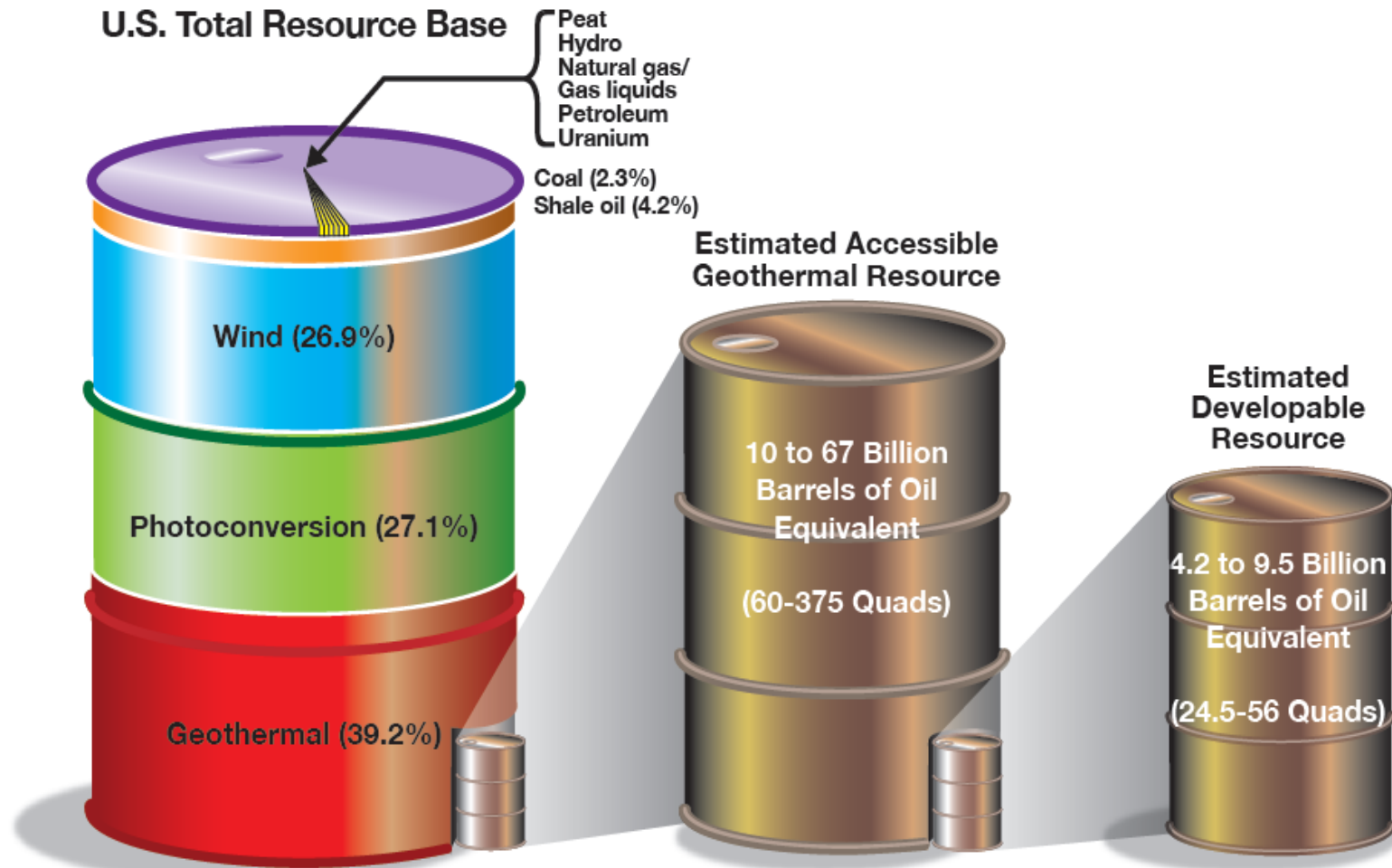
Dr. Roy Mink

U.S. Geothermal Potential



Areas in red and orange are where, with today's technology, we can find and use geothermal reservoirs.

U.S. Energy and Geothermal Resources

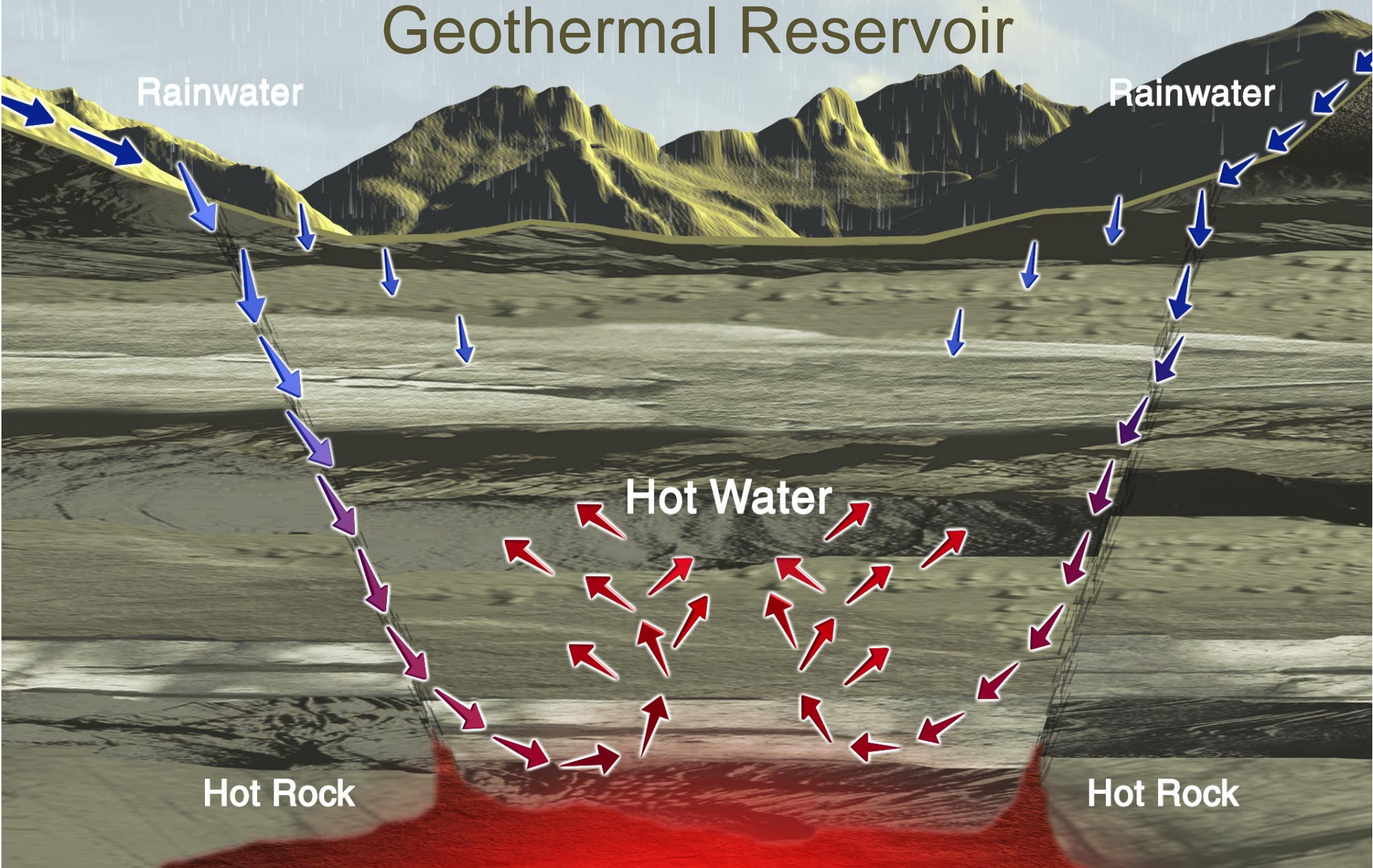


Source: *Characterization of U.S. Energy Resources and Reserves*, December 1989, U.S. Department of Energy, DOE/CE-0279.

Geothermal Reservoir

Rainwater

Rainwater



Hot Water

Hot Rock

Hot Rock

When the hot water and steam accumulate in permeable and porous rock, a geothermal reservoir forms.

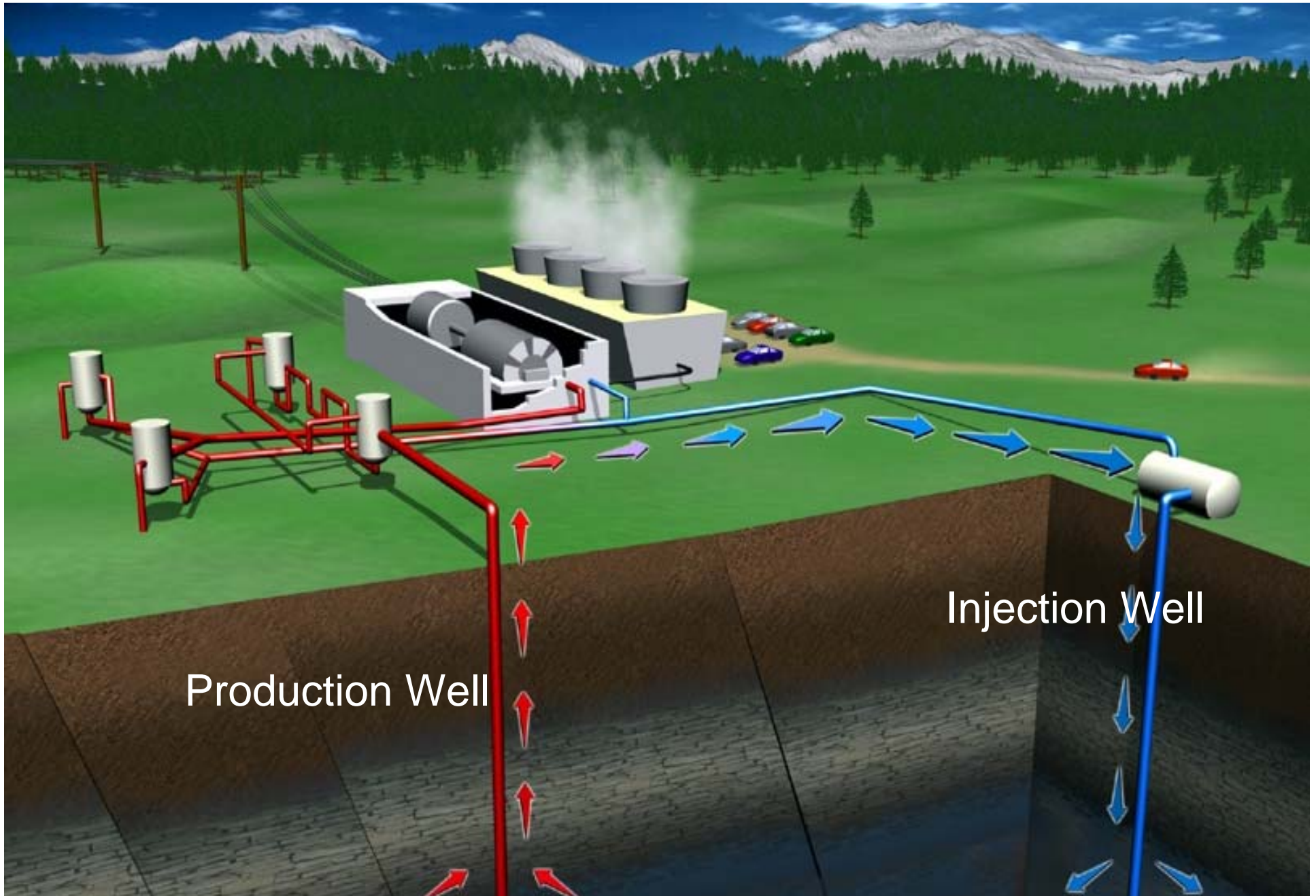
Geothermal Systems

Low Temperature

- Direct Use
 - District Heating
 - Bio-fuels Production
 - Greenhouse
 - Aquiculture
 - Agriculture
 - Process Heat
 - Geothermal Heat Pump

High Temperature

- Power Systems
 - Flash
 - Binary
- Distributed Power
- Mineral Recovery
- Hydrogen Production



Natural steam from the production well powers the turbine generator. Condensed steam and unused hot water are injected back into the reservoir, thus sustaining production.

Binary Cycle Power Plant

Binary Vapor

Turbine

Generator

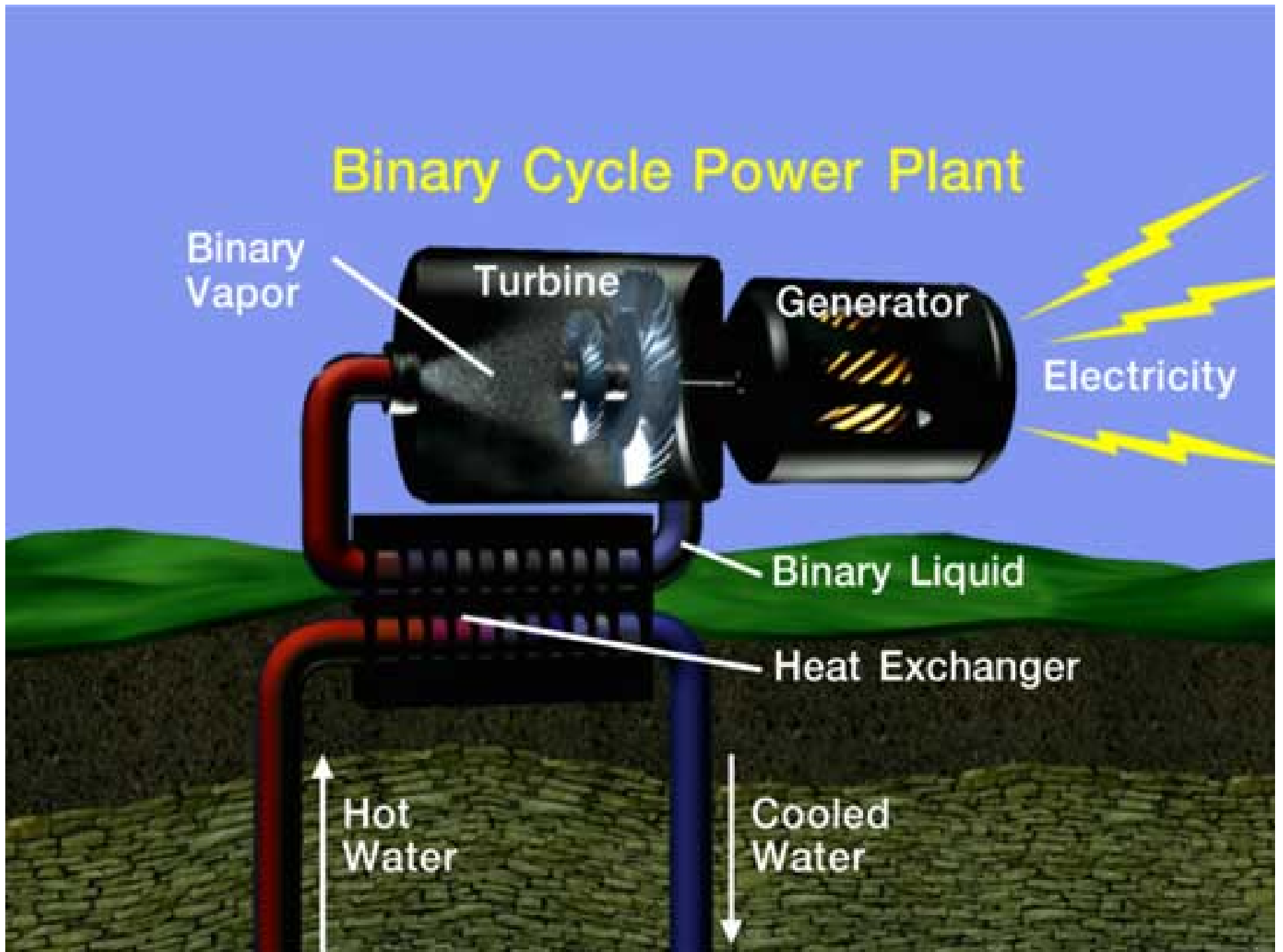
Electricity

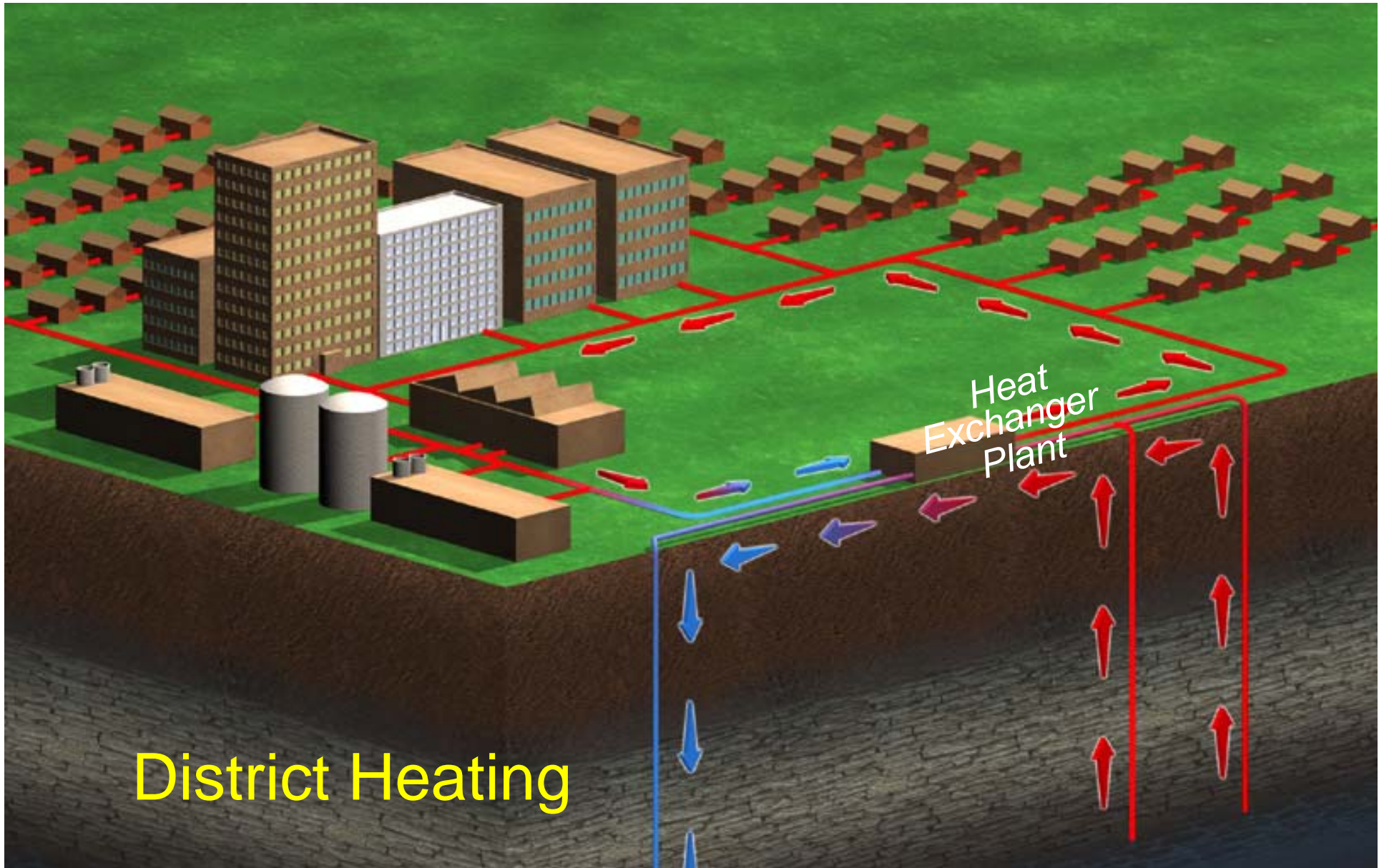
Binary Liquid

Heat Exchanger

Hot Water

Cooled Water



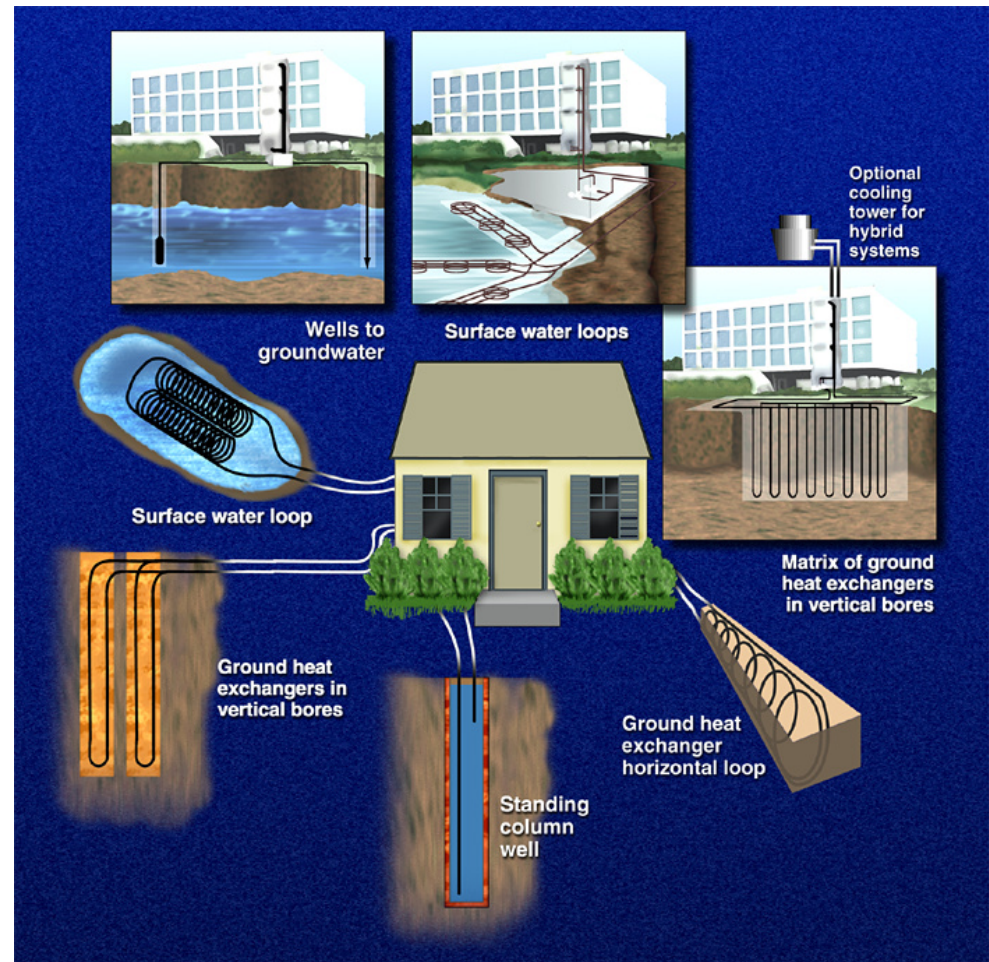


District Heating

In a geothermal district heating system, hot water from one or more geothermal wells is piped through heat exchanger plant to heat city water. The hot city water is then used to heat the buildings.

Geothermal Heat Pumps

- Among the most efficient heating and cooling technologies available
- 600,000 to 800,000 geothermal ground source heat pumps now in use throughout the United States
- Replaces both furnace and air conditioner
- Earth serves as heat source in winter, heat sink in the summer
- Fluid circulates through underground piping. An indoor system extracts energy from the fluid for heating, or adds energy for cooling.



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





Greenhouses at Chena Hot Springs, Ala



More commonly, geothermal water is used to speed the growth of fish. These trout, prawns, and tilapia are from geothermally heated hatcheries and fish farms in California, Colorado, and Oregon.





Geothermal heat is also used in industry — to dry lumber or food products, for example. This plant in Brady, Nevada, provides dried onions to McDonalds and Lipton Soups.

Geothermal power plant Chena, Alaska



Geothermal Strategic Value

- **Clean** electricity generation
- **Baseload** power production, high capacity factors
- **Distributed** energy systems with **modular** and shorter development timeframe advantages.
- **Direct-use** building energy needs
- **Ethanol & biodiesel** production (thermal energy requirements)
- **Hydrogen** production (via off-peak electrolysis)
- **Enhanced oil recovery**, thus gaining more oil
- **Climate change** mitigation
- **Rural economic development** (e.g., aquaculture and horticulture, timber/lumber drying)
- **Mineral recovery** (e.g., silica and zinc – both strategic minerals in short supply)



To maintain a clean and secure supply of energy, we must conserve, use energy efficiently, reduce our reliance on fossil fuels, and increase use of renewable resources like geothermal energy.