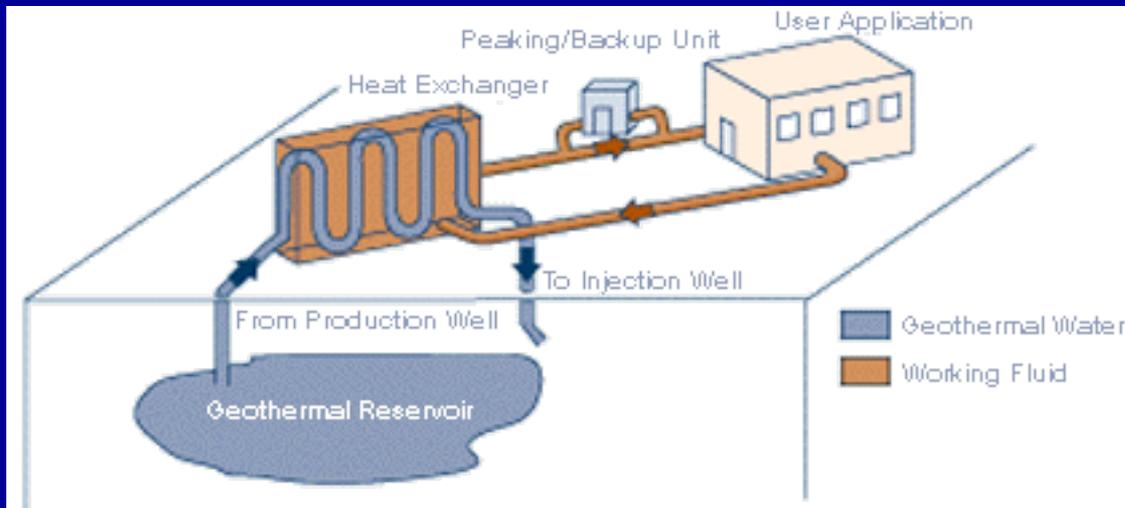


Direct Use of Geothermal Energy



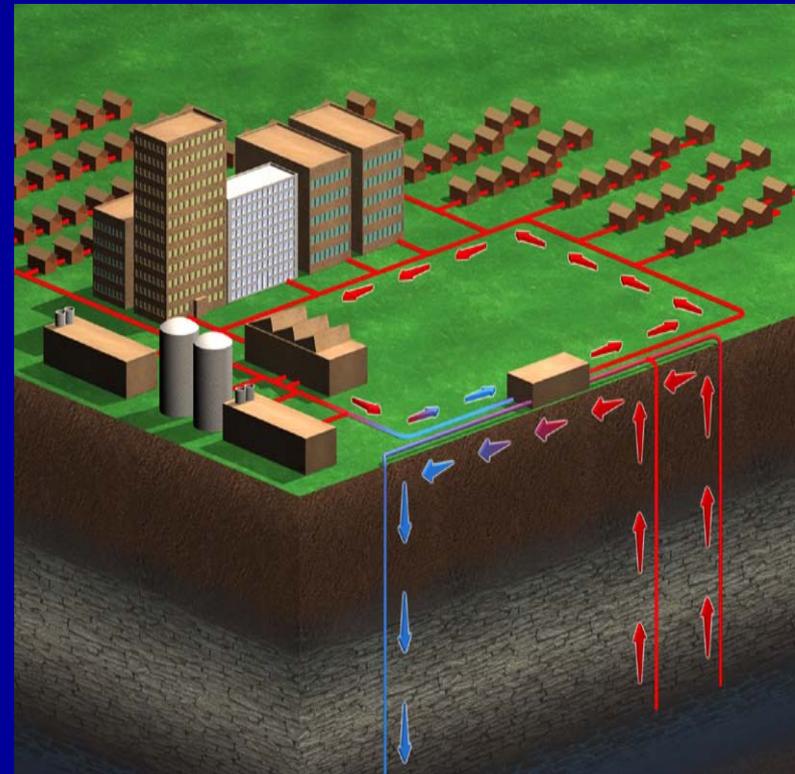
Greenhouses



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

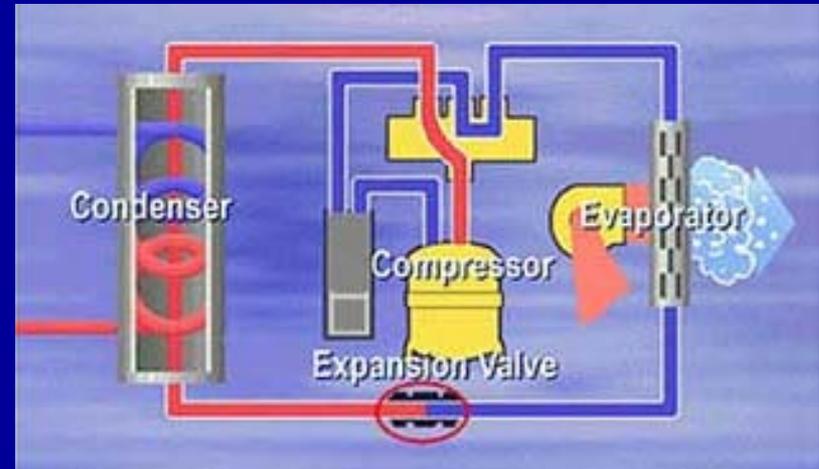
- \$2.0 billion domestic annual energy sales
- Baseline power – 90%+ capacity factor
- 6% of California electricity generation, 10% northern Nevada, 25% island of Hawaii
- Over \$600 million in cumulative royalties to Federal government
- Four million customers served annually

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

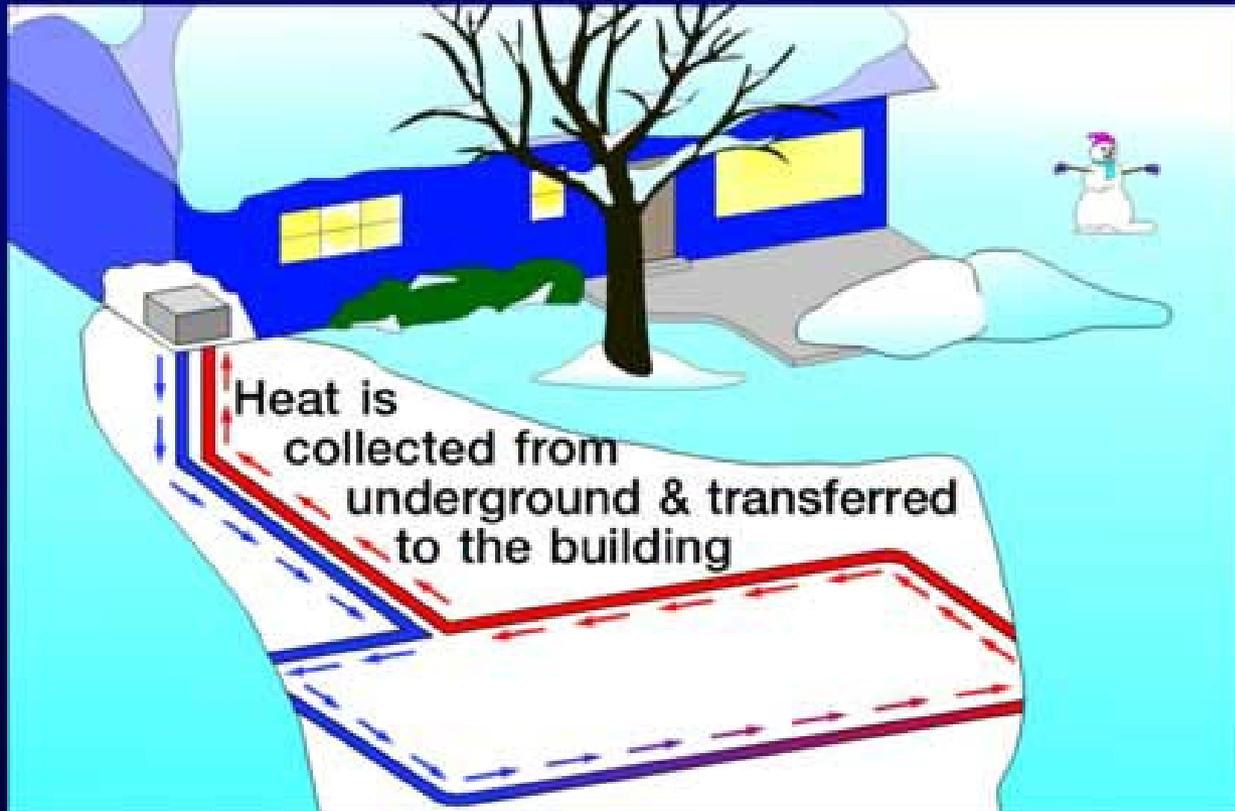


Diagram courtesy of the the Geothermal Education Office

Heat Pump in Summer

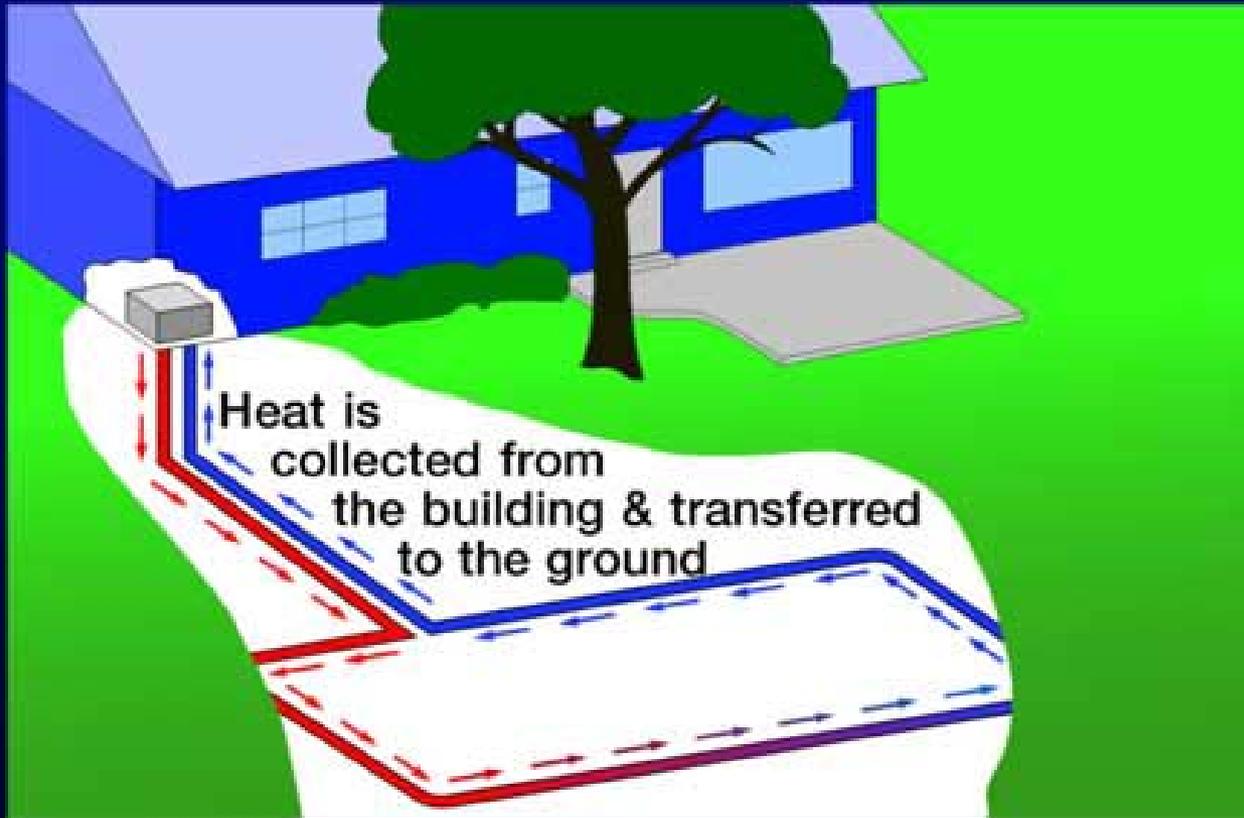


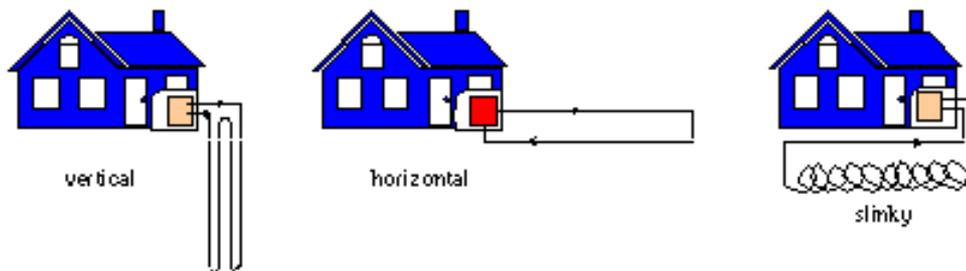
Diagram courtesy of the the Geothermal Education Office

GEOTHERMAL HEAT PUMPS (GHP)

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

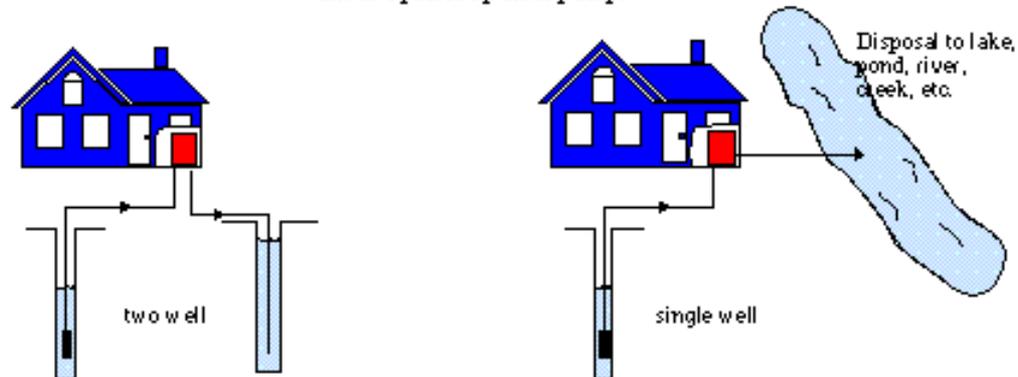
Ground Coupled Heat Pumps (GCHP)

a.k.a. closed loop heat pumps



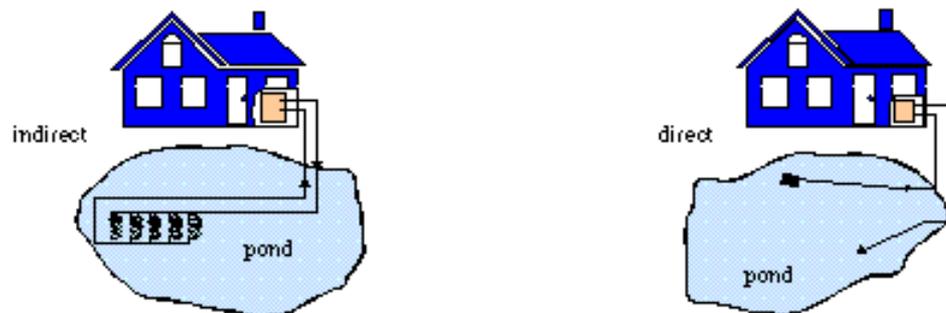
Groundwater Heat Pumps (GWHP)

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 Potawatomí, Oklahoma FireLake Golf Course Club House





6 2:34 PM



6 2:35 PM





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