



Geothermal Energy

# Geothermal Energy: Introduction

- What is geothermal energy?
- **Geothermal energy**- energy that comes from the ground; power extracted from heat stored in the earth
  - Geo: earth
  - *Thermal*: heat



# Geothermal Energy Generation

## Direct

- Small scale uses
- Heating homes
- Hot springs
- Greenhouse heating
- Food dehydration plants
- Agriculture
  - ▣ Crop drying
  - ▣ Milk pasteurization

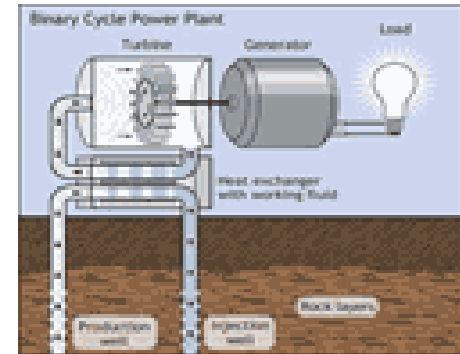
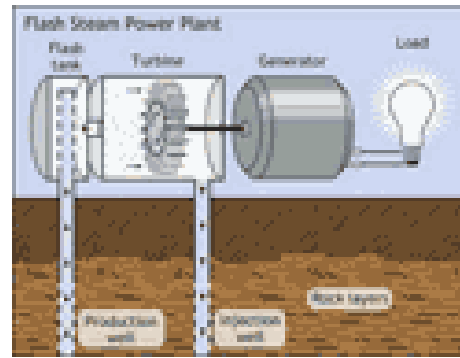
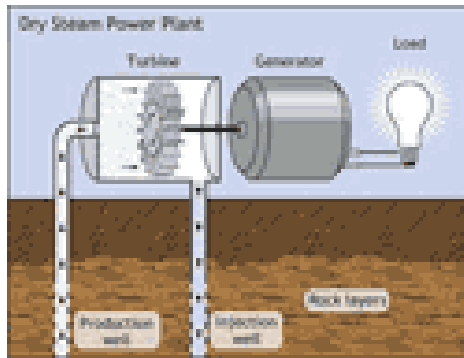
## Electrical

- Dry steam
- Flash steam
- Binary cycle

# How Geothermal Works

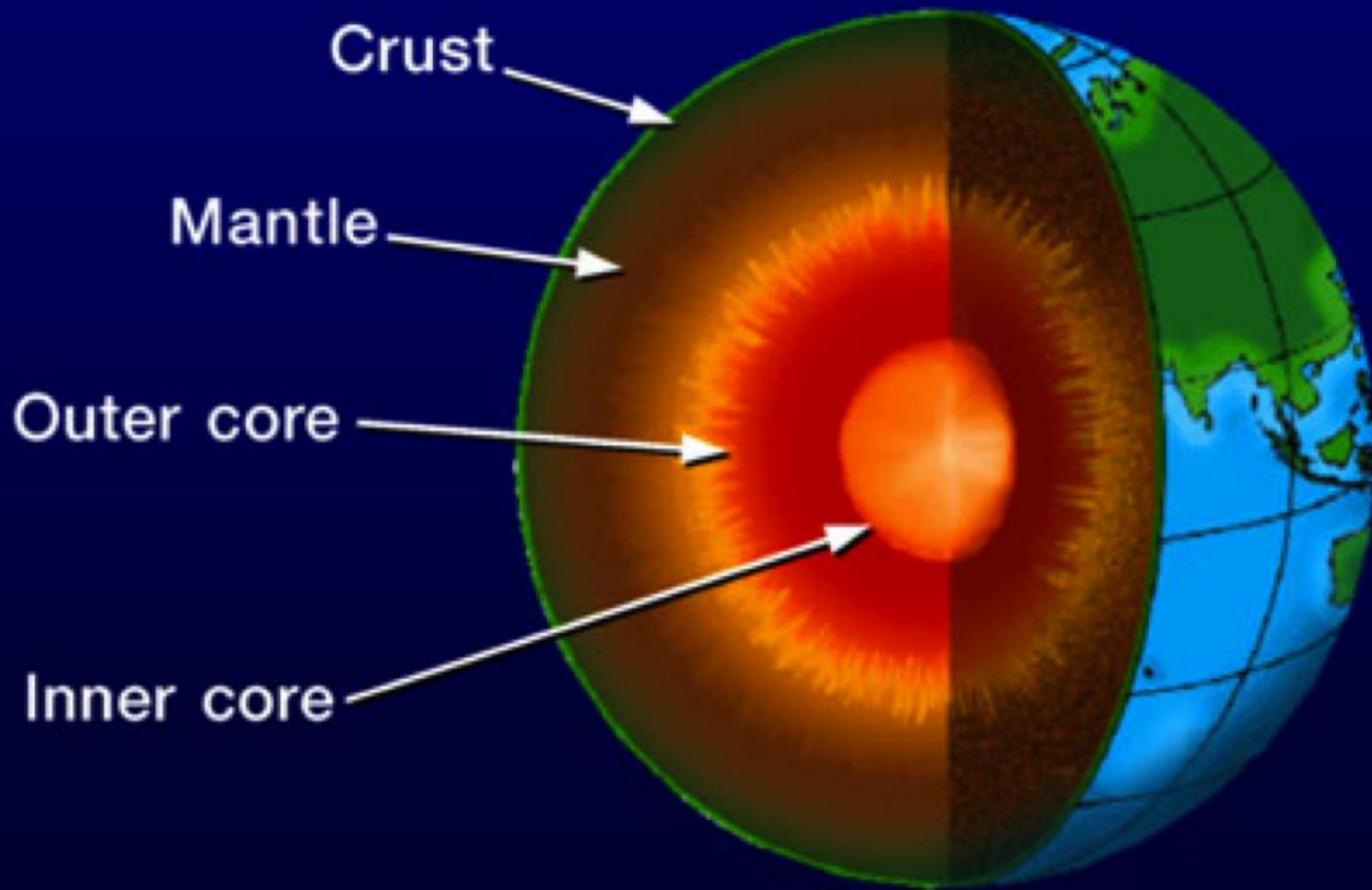
- Earth's core heat
- Water → steam → drive electrical generators
- Turbines
- Area specific
  - ▣ Geothermal energy is localized

# Dry Steam/Flash Steam/Binary Cycles

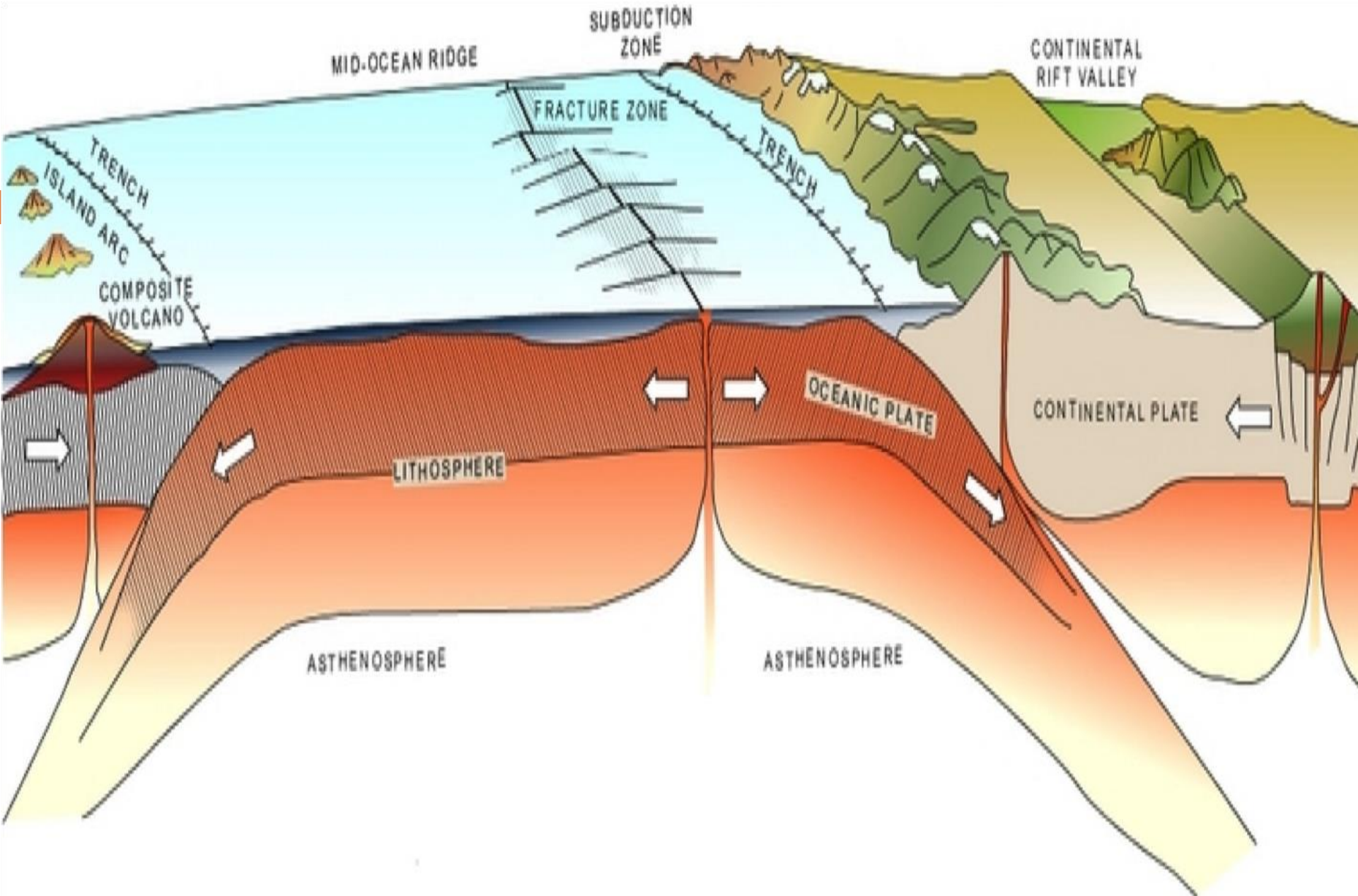


- Each uses the heat from underground in some manner to generate energy
- Different combinations of water temperatures create different effects
- How Geothermal Energy Works

# The Earth





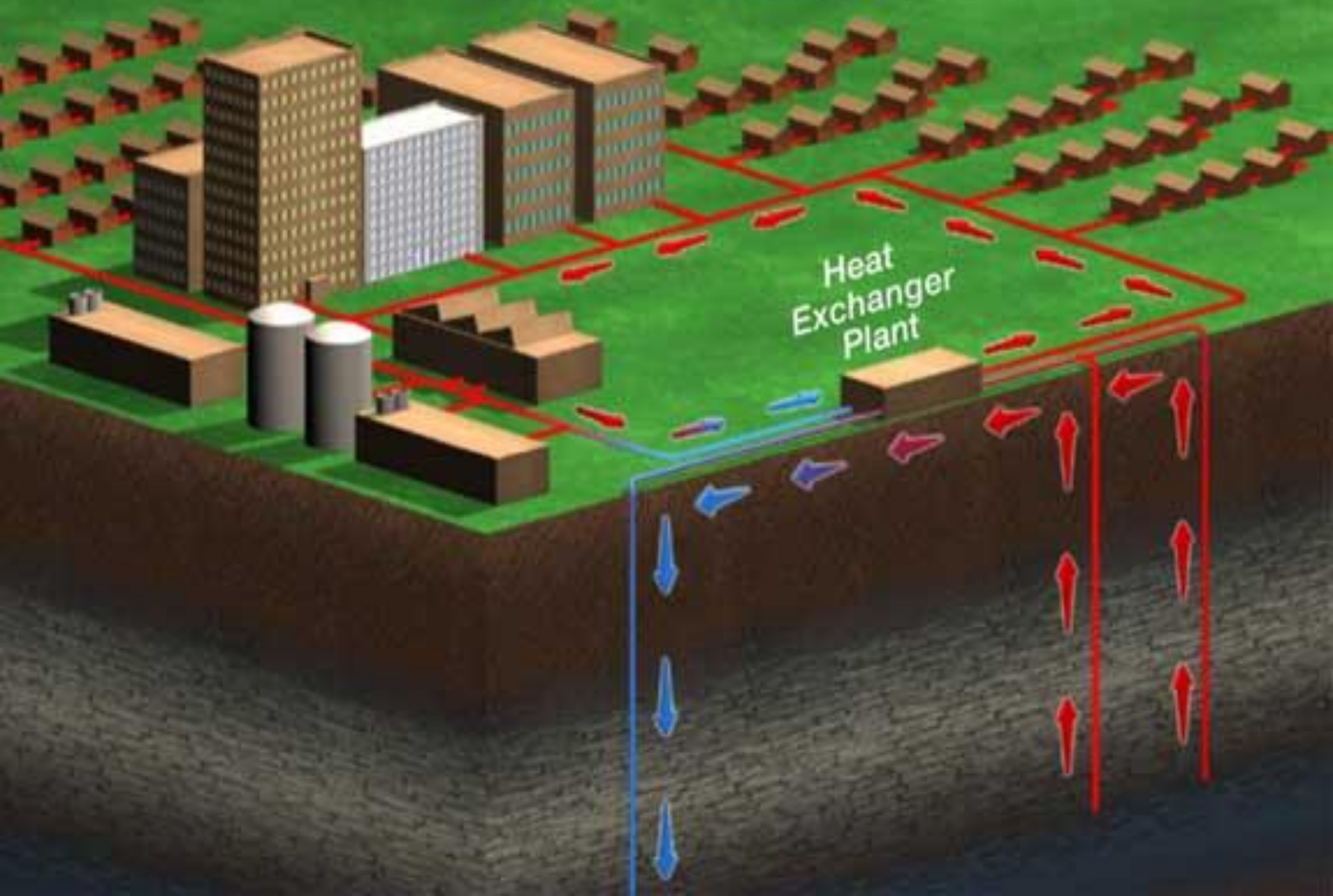


# Geothermal Energy: History

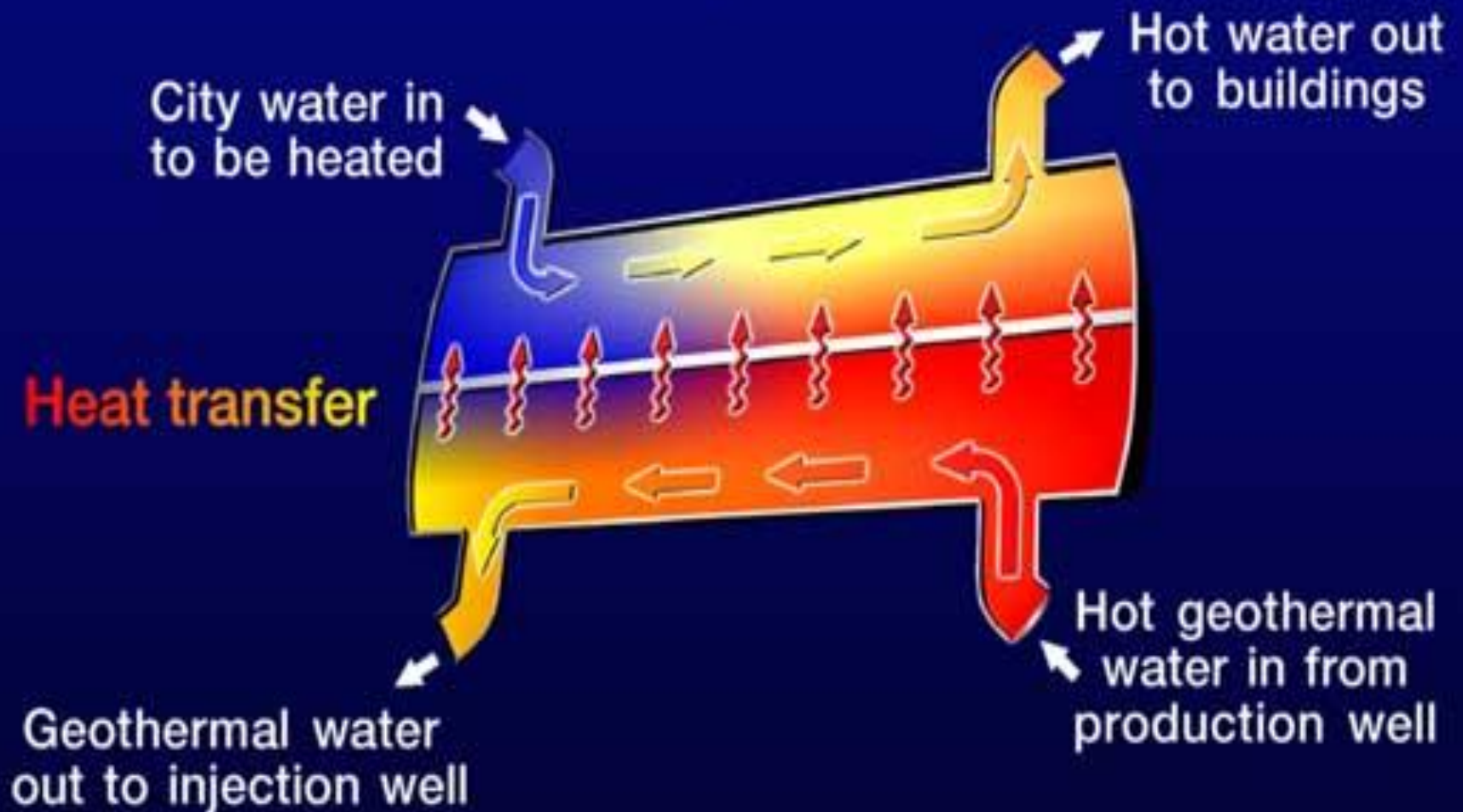
- Used for bathing in Paleolithic times
- Ancient Romans used it as a central heating system for bathing and heating homes and floors
- 1892: America's first district heating system was put into place

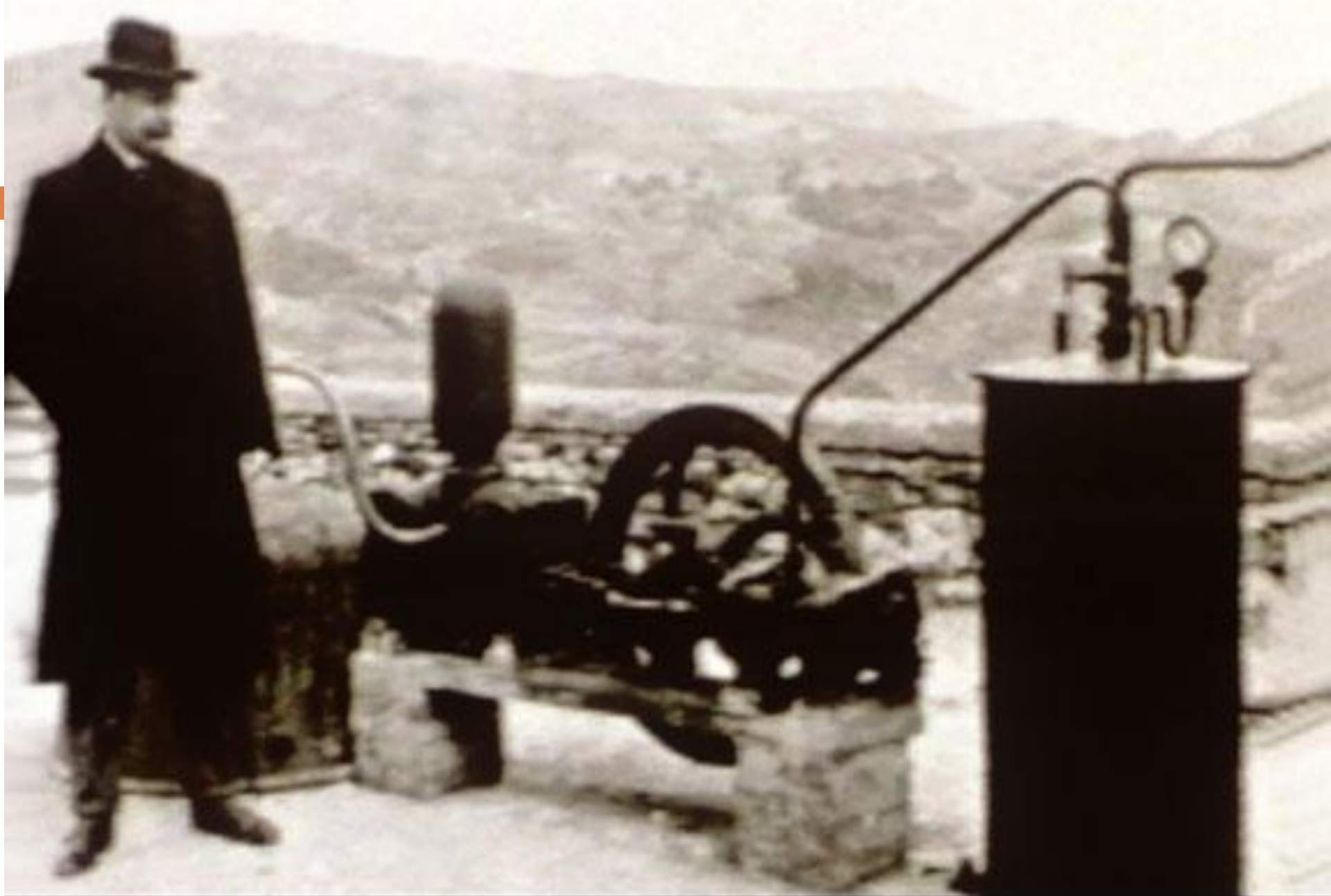


# District Heating



# District Heating Heat Exchanger





First Geothermal Power Plant, 1904, Larderello, Italy





Example of a Power Plant in Larderello Today

# Geothermal Energy: History

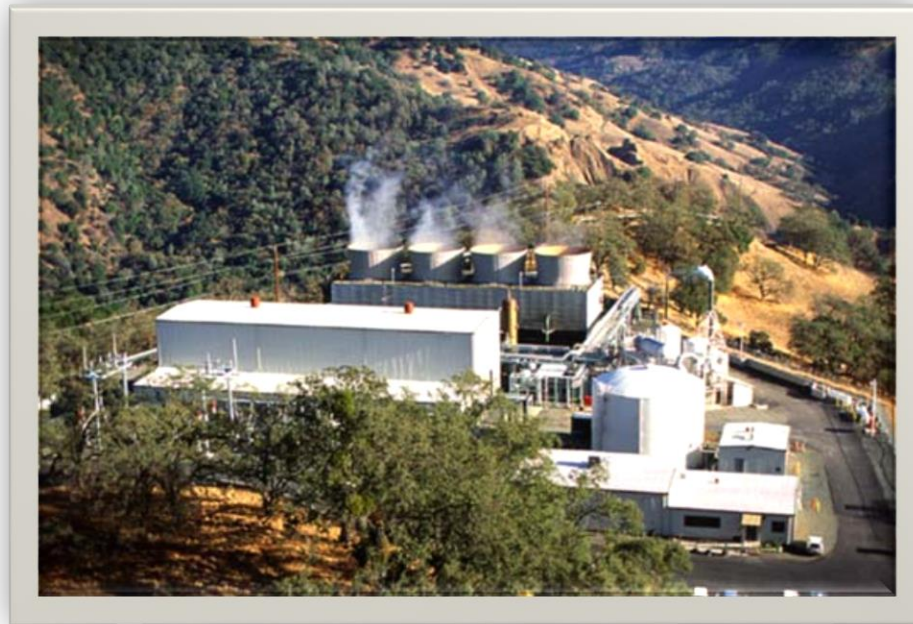


- 1926: a deep geothermal well was used to heat greenhouses.



# Geothermal Energy: History

- 1960: Pacific Gas and Electric has first successful geothermal electric power plant in US at The Geysers
  - ▣ Turbine lasted more than 30 years



# United States and Geothermal





# United States and Geothermal

- The US is now the world's largest geothermal producer
- Current bills are being processed to give research towards geothermal projects \$500 million
- Pushing large scale production



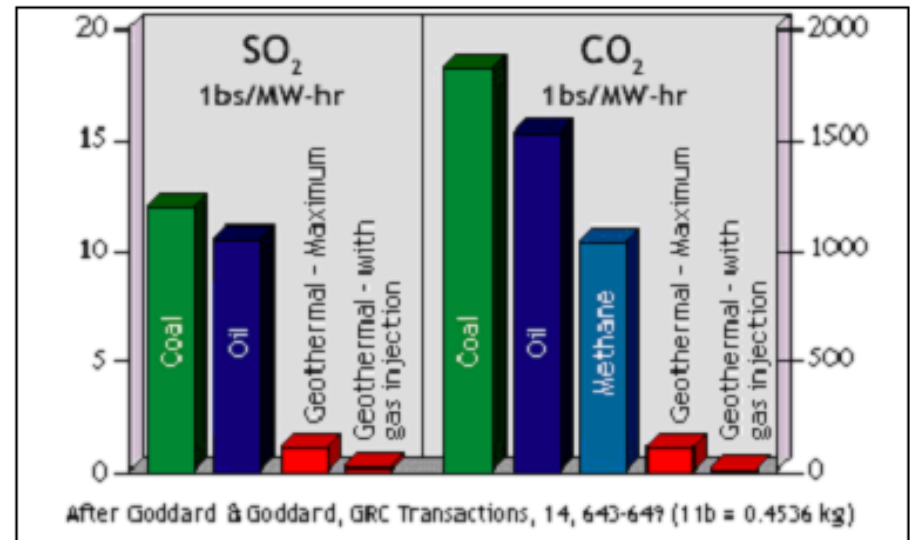
# Can Geothermal Energy run out?

- 100% renewable
  - Earth's core is always going to be heated
  - As long as there is a way to extract the energy from the heat, the energy will always be available



# Environmental Effects/ Benefits

- Remarkable difference of environmental effects compared to fossil fuels
  - Leaves almost no footprints
- Most hardware used to extract geothermal energy is underground
  - Minimal use of surface



(<http://www.geothermal.nau.edu/about/enviroment.shtml> Northern Arizona University. 2009 Oct 27)


# Environmental Effects/Benefits

Power Source	Land Requirement (ac/mW)
Geothermal	1-8
Nuclear	5-10
Coal	19

- Easy to operate
- Open up economy
- Much more efficient use of land

(<http://www.geothermal.nau.edu/about/environment.shtml>) Northern Arizona University.  
2009 Oct 27)

# Environmental Effects/ Disadvantages

- Fluids drawn from the deep earth carry a mixture of gases
- Pollutants contribute to global warming and acid rain
- Construction of Plants can adversely affect land stability
- Sources may hold trace amounts of toxic chemicals/mineral deposits
- Loud Noises 
- Initial start up cost (expensive)

(<http://www.geothermal.nau.edu/about/enviroment.shtml>> Northern Arizona University. 2009 Oct 27)

Operation	Noise Level (dBa)
Air drilling	85–120
Mud drilling	80
Discharging wells after drilling (to remove drilling debris)	Up to 120
Well testing	70–110
Diesel engines (to operate compressors and provide electricity)	45–55
Heavy machinery (e.g., for earth moving during construction)	Up to 90

# What social/political problems are posed?

## Social Problems

- Aesthetics

## Political Problems

- Another funding avenue for government
  - ▣ Initial start up cost is costly
- Regulation
- Dispersion

# Do any laws or regulations prevent the deployment of geothermal energy?

- Depends on state and specific community: not any federal laws
- Factors to consider
  - ▣ Noise
  - ▣ Aesthetics
  - ▣ Proximity to houses
  - ▣ Waste regulation (some use coolants)



# Can production be enhanced in those areas already developed?

- Yes the output is growing by 3:1 every year
  - ▣ Plants are already improving their capacity factors
  - ▣ Normally, plants are built on edges of tectonic plates  
→ allows geothermal energy extraction to be easier
  - ▣ The development of the binary cycle power plants and improvements in drilling and extraction technology allows geothermal systems to develop in a wider range

# Can production be developed in areas where geothermal is minimally developed?

- Areas with high Geothermal energy potential
- Many “hot spots” have not even been hit yet
- Ring of Fire: good hydrothermal resources
- But with continuing research and deeper drilling abilities, these “hot spots” won’t even matter
  - Drills will be able to reach farther down to draw energy from any source, whether or not is developed or a “hot spot”



# What evidence supports geothermal?

- New facilities produce electricity for \$.045/kW hour
- Price is declining compared to price of fossil fuels, which is increasing
- The US can produce and 950,000 megawatts of power but are currently only producing 2,800 megawatts of power
  - ▣ This number is going to constantly increase with new technologies and research

# Opposition to Geothermal Energy

- Not everyone agrees that geothermal energy is a solution to our energy crisis
- Too costly
- Noise
- Use of fresh water
- Land surveying
- The technology is not quite there
- Some people just believe that our fossil fuels will “never” run out
  - ▣ Don't believe that fossil fuels are finite

# Conclusion

- ❑ Overall, geothermal appears to be a sound solution to energy needs
- ❑ Geothermal energy has the ability to expand
- ❑ Few environmental effects
- ❑ Very cost efficient
- ❑ Geothermal is RENEWABLE



# Citations

- [Wikipedia article on Geothermal Power](#)
- [Geothermal Education Office website](#)
- [US Department of Energy Geothermal Technologies Program website](#)
- [International Geothermal Association website](#)
- [Renewable Energy Access website on geothermal energy](#)
- [Online chapter on geothermal energy by Energyquest](#)
- [Union of Concerned Scientists geothermal website](#)
- [Geothermal Energy Association](#)
- [World of Energy factsheets](#)
- [Andy Darvill web resource on geothermal](#)
- [Clean Energy Ideas web resource](#)
- [Article on geothermal advantages and disadvantages](#)
- [Comments by Jasmin Malik Chua](#)
- [Article in USA Today](#)
- [Website from Northern Arizona University](#)
- [Link to report evaluating sedimentation caused by geothermal in](#)