Geothermal Energy Overview

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Roger Hill

Geothermal Power
Sandia National Laboratories

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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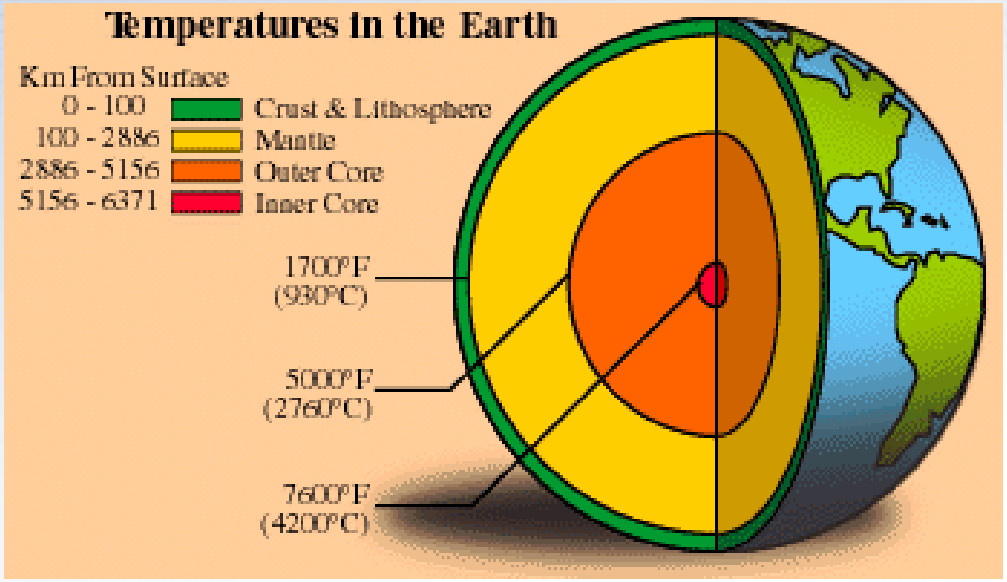
Geothermal Energy

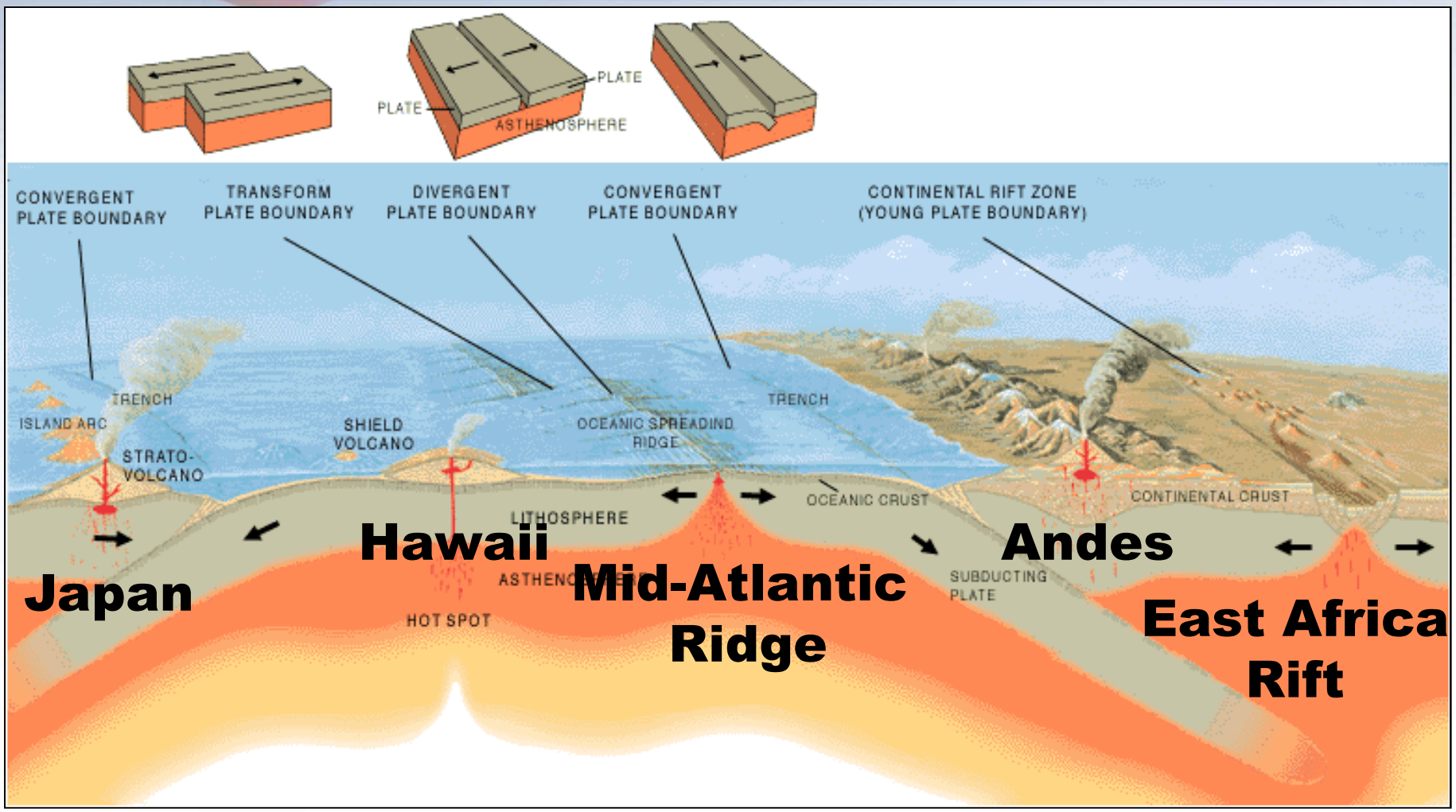
Uses the Earth's natural heat for:

- **Agricultural and industrial processes**
- **Electricity generation**
- **Space and hot water heating**



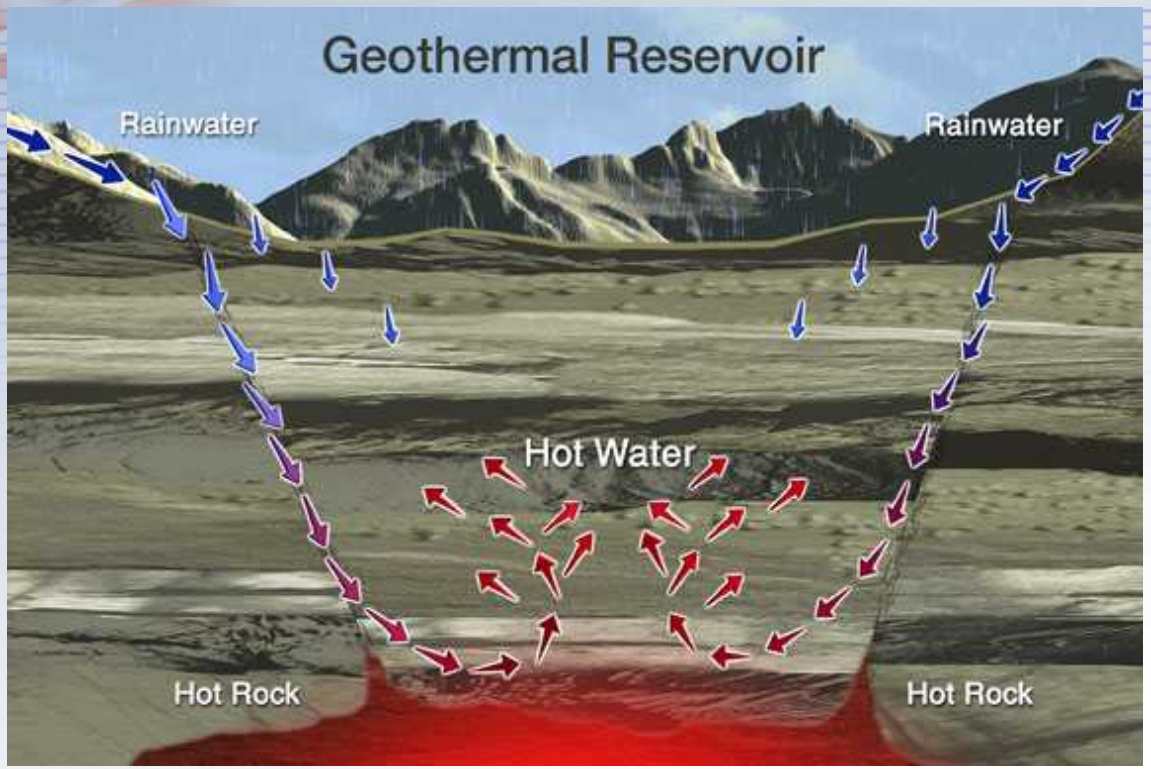
Hot rock is everywhere, but there are only a few places where it is hot enough (220° F) near the surface for extracting energy to be economical.

Tectonic Plate Boundaries



Source: Fraser

How Geothermal Sites Are Created

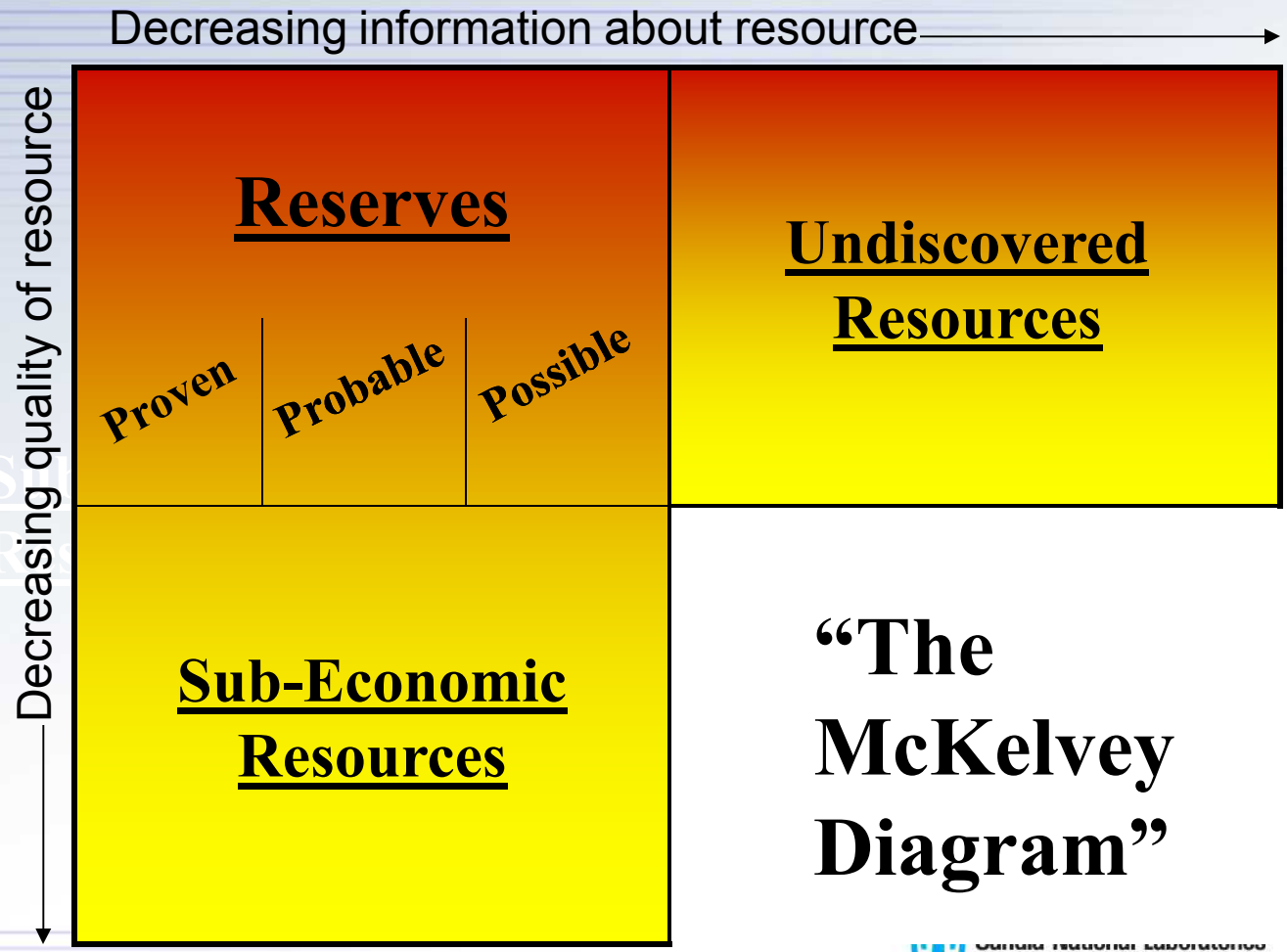


Geothermal resources are found where geological activity has brought hot rock near the surface. When hot water and steam is trapped under a layer of impermeable rock, it forms a geothermal reservoir.

Geologic Assurance and Economic Feasibility

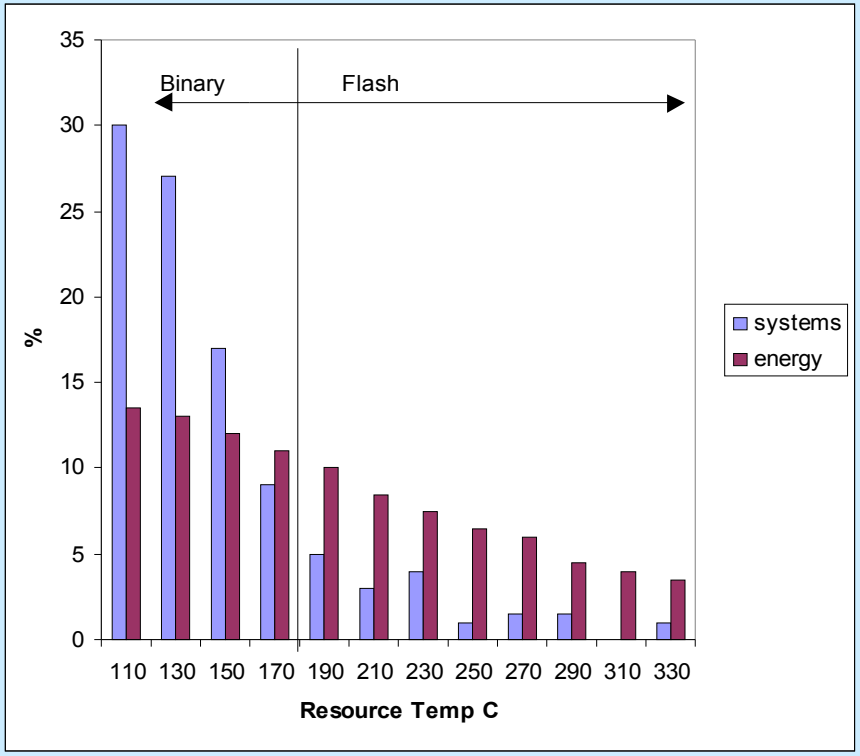
National R&D helps to expand the geothermal resource base:

- ✓Geophysics and geoscience to locate and define reservoirs
- ✓Drilling research to reduce costs
- ✓ Improving capabilities and efficiencies of power plants.



"The McKelvey Diagram"

Low-Temp Resources are More Common

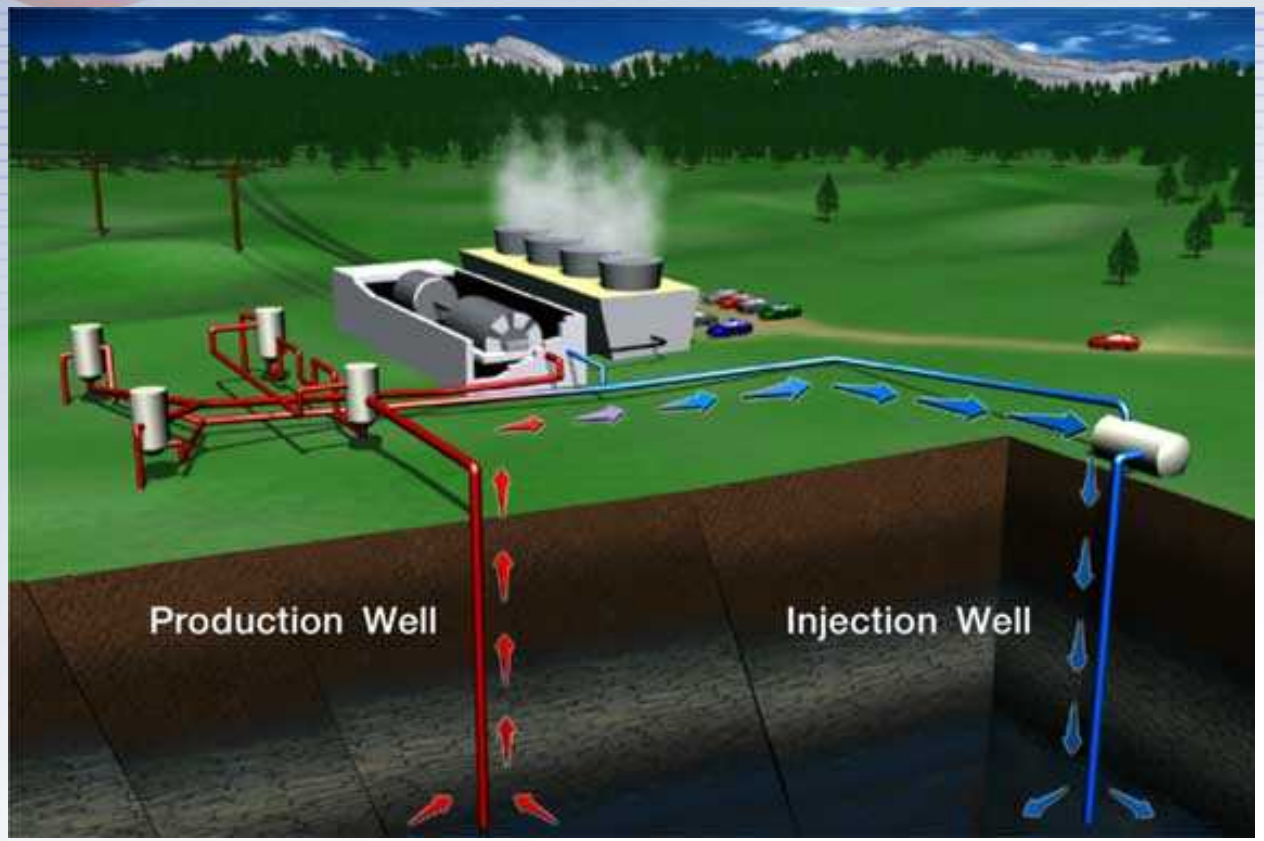


Frequency of occurrence and energy of hydrothermal convection systems identified by the USGS in 1978

- 83% of the sites require binary plants (also, EGS/HDR will most likely need binary plants)
- And 50% of the available energy is below temperatures requiring binary plants (170C)

Source: NREL

Geothermal Energy



Our focus in on electricity generation using hydrothermal and engineered geothermal systems (EGS)

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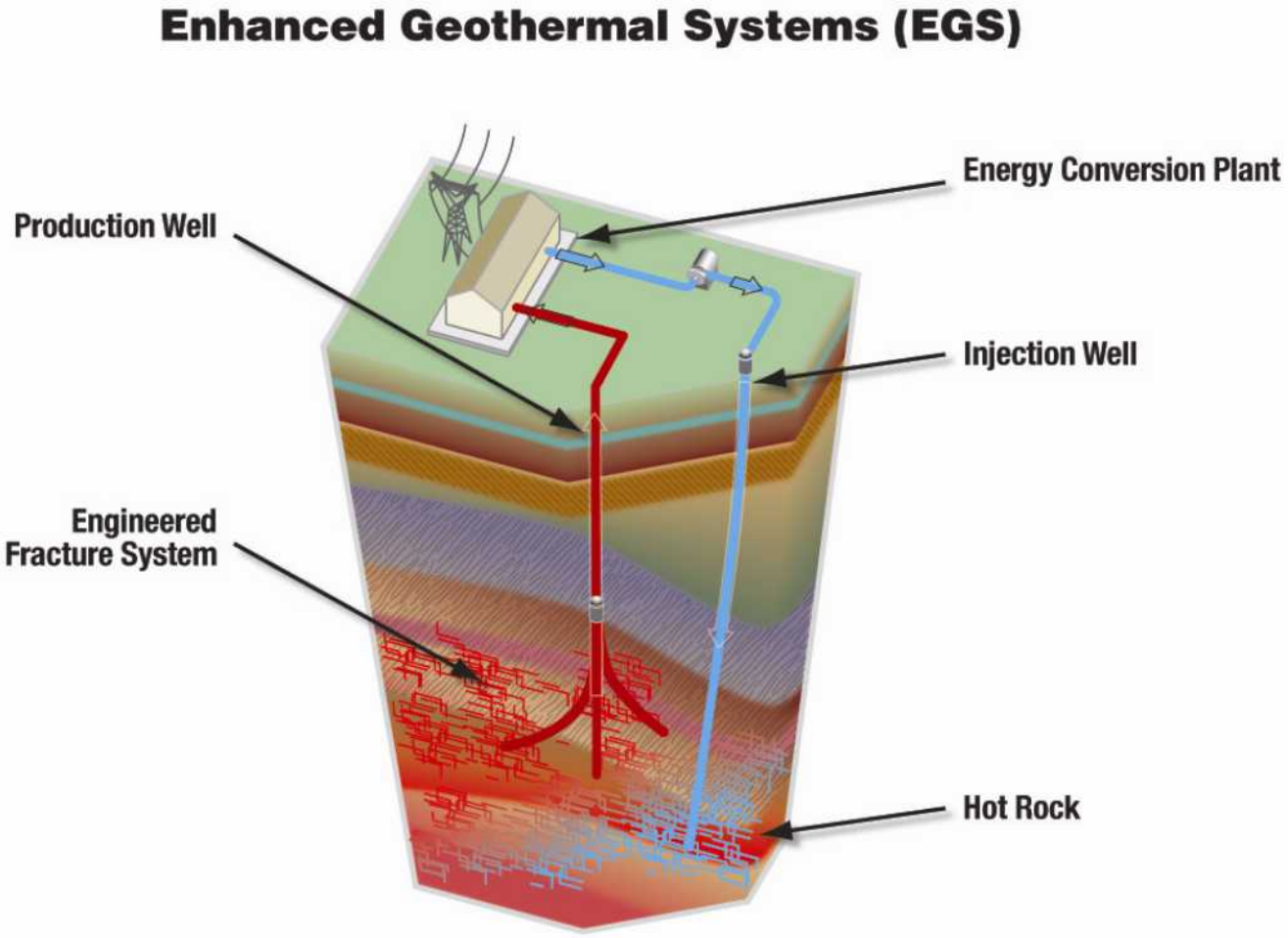
EGS System Components



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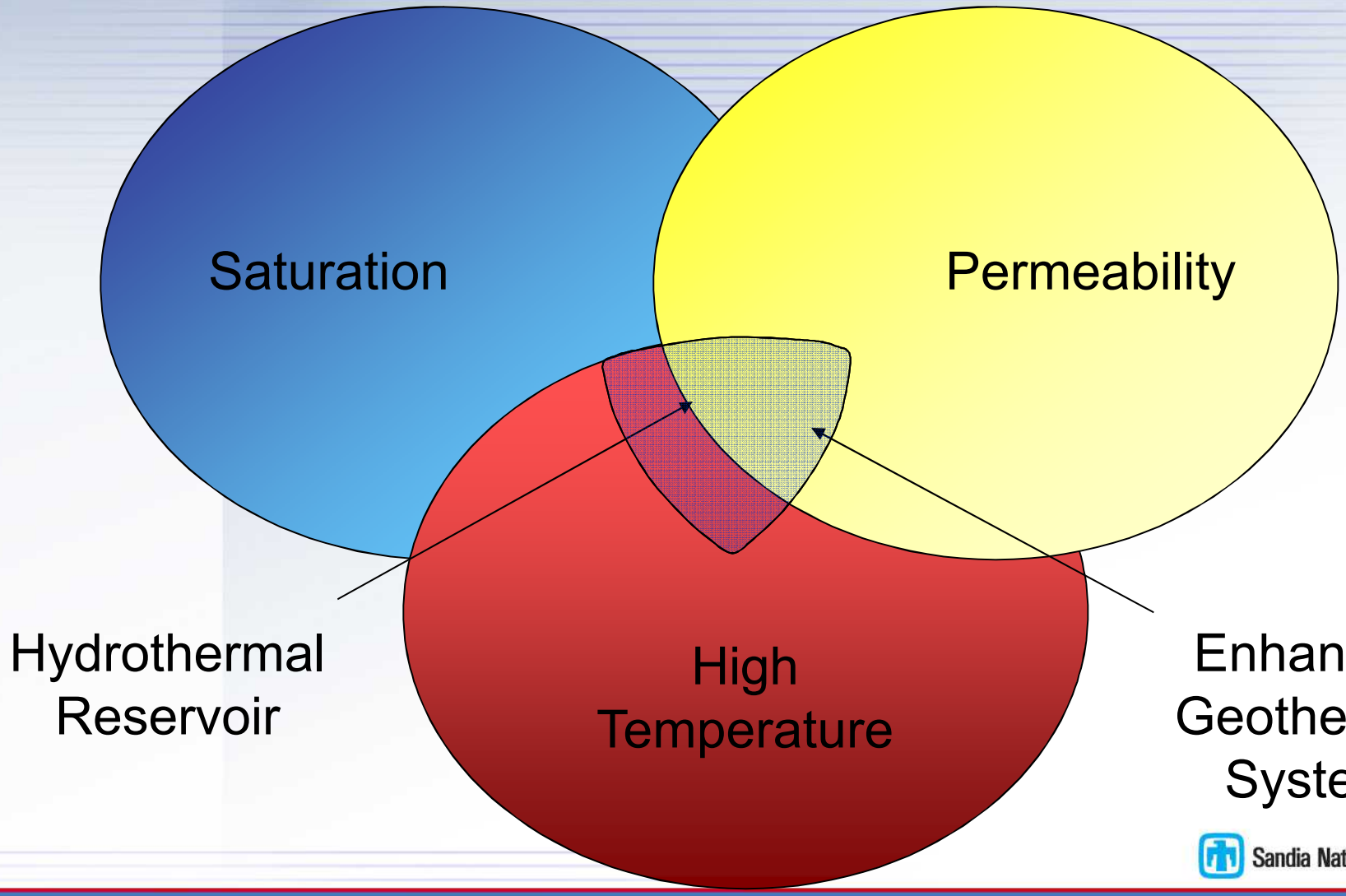
Geothermal Domains



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November 2003

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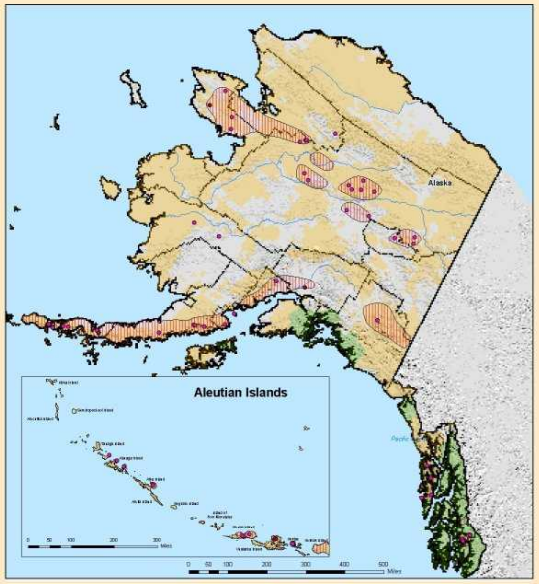

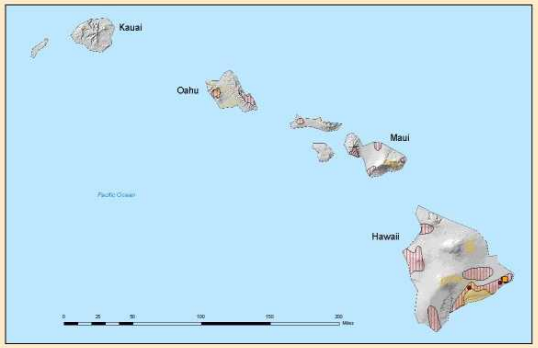

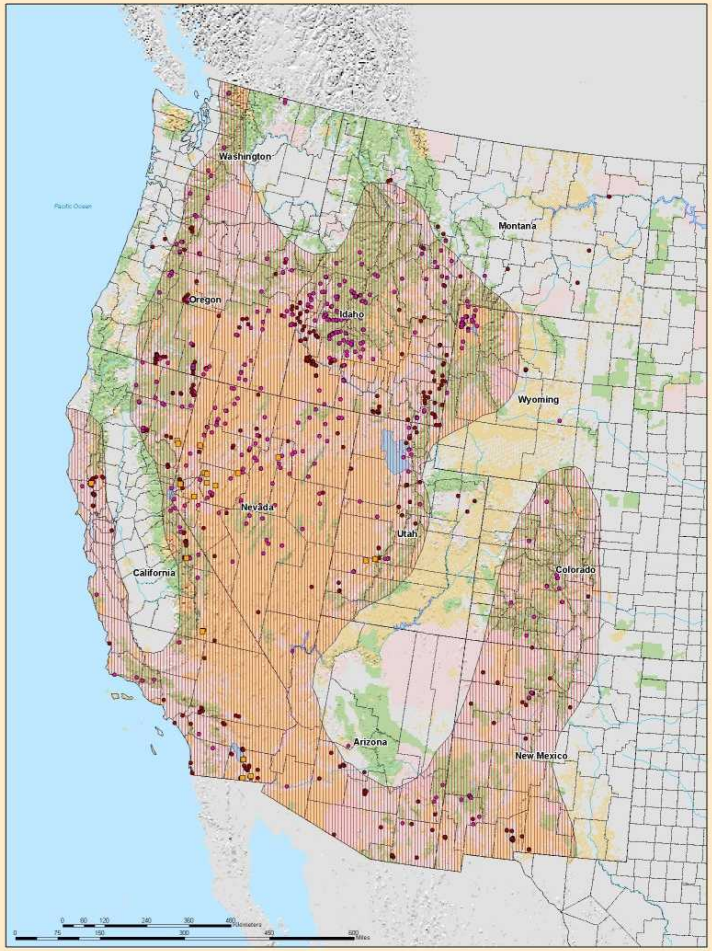

Legend

- Rivers/Streams
- County Boundaries
- State Boundaries
- Lakes/Reservoirs

Geothermal Categories

- Electrical Generation
- Regions of Known or Potential Geothermal Resources
- Wells > 50 Degrees C
- Springs > 50 Degrees C

Ownership

- State and Private Lands
- Bureau of Land Management and Other Federal Lands
- Major Lakes and Reservoirs
- Native American Lands
- U.S. Forest Service Lands

Map Prepared by Patrick Laney and Julie Brizee at the Idaho National Engineering and Environmental Laboratory
For
The U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Geothermal Technologies Program

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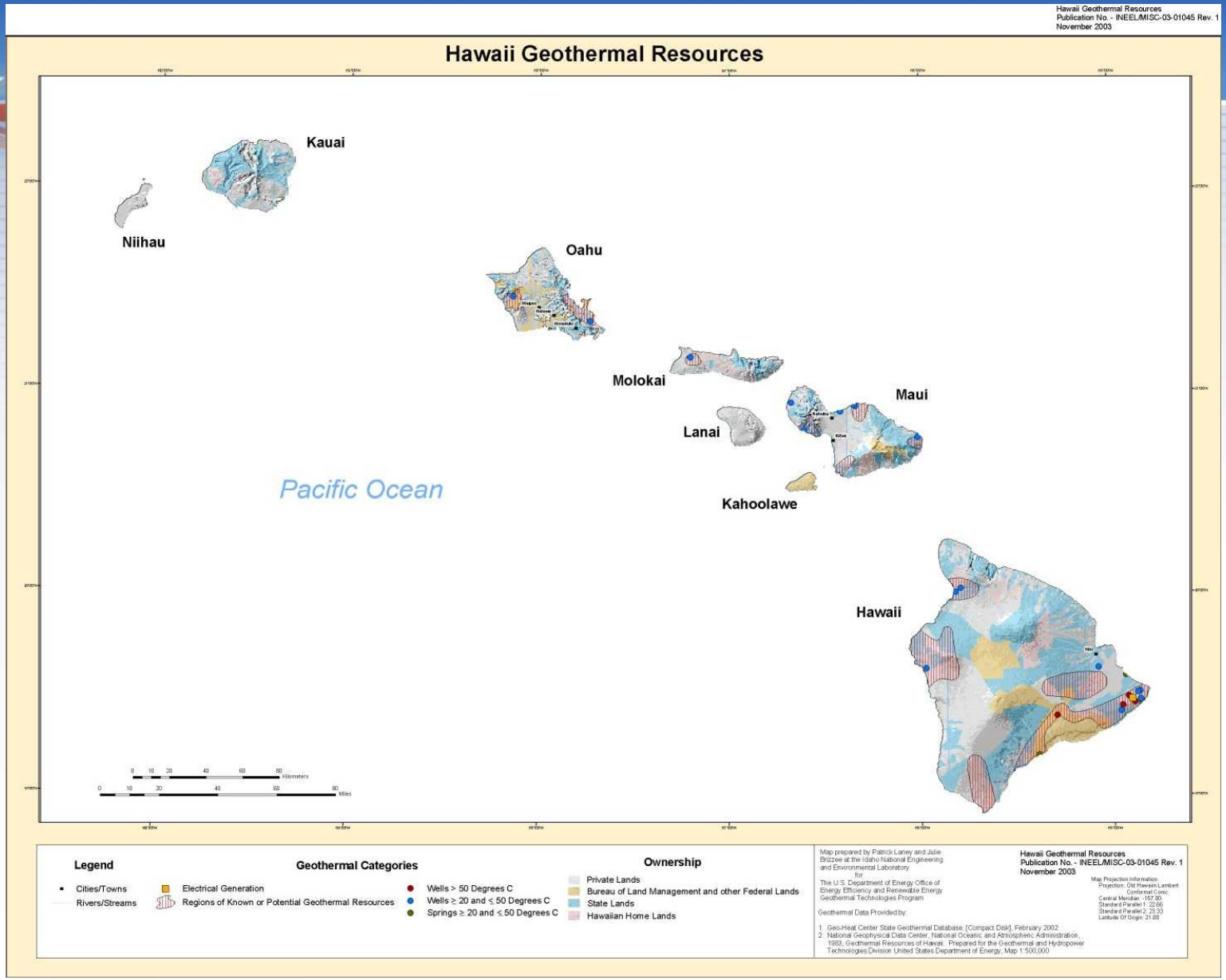
Map Projection Information:
Projection: Albers
Central Meridian: -96.00
Standard Parallel 1: 20.00
Standard Parallel 2: 60.00
Latitude Of Origin: 40.00



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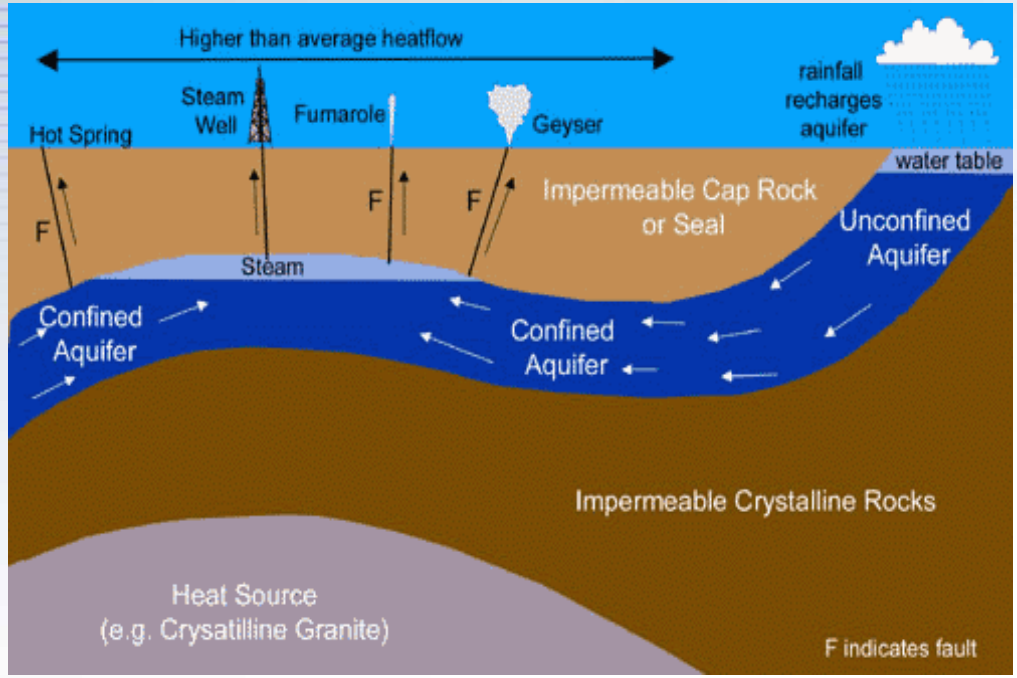
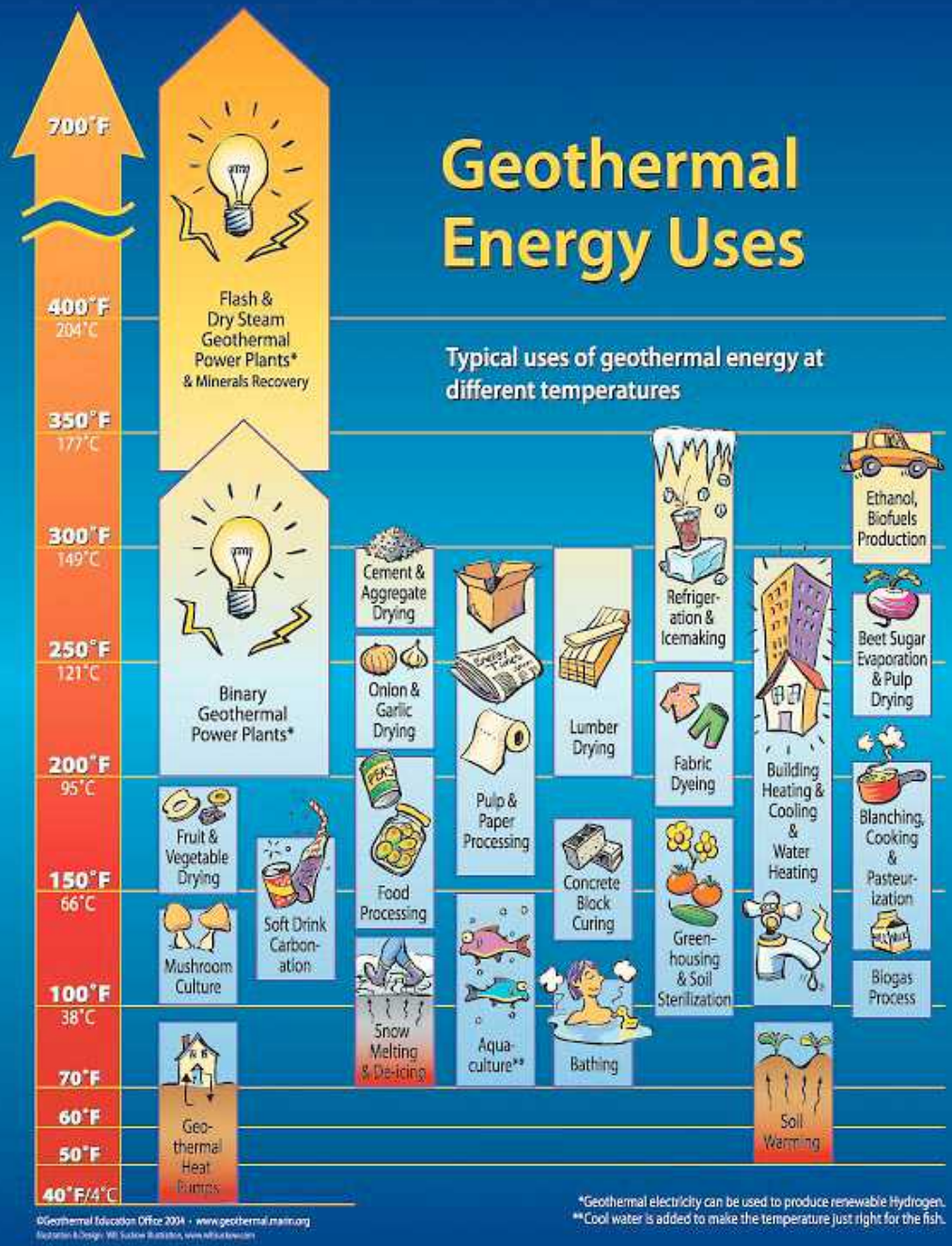
Generic Geothermal Site



Geothermal resources are typically found where hot rock or magma has come near the surface through geologic activity. We gain access to the resource by drilling into it, unless there is a surface manifestation, such as a hot spring, that can be used directly.



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Attributes of Geothermal Power

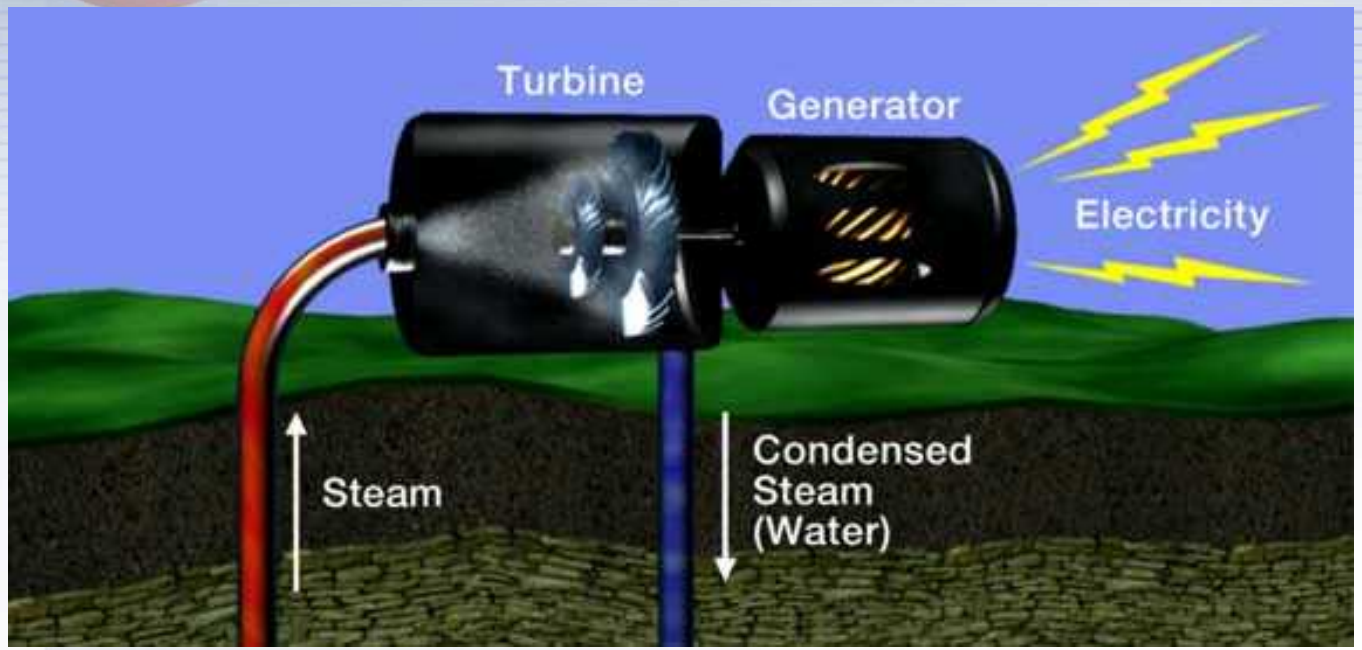
Advantages

- Enormous potential
- High, reliable plant capacity factor
- Greenhouse gas reduction
- Low environmental impact
- Much mature technology

Disadvantages

- Expensive drilling
- Regional resource
- Resource uncharacterized
- Threshold plant size
- Plant prefers constant load
- Environmental perception

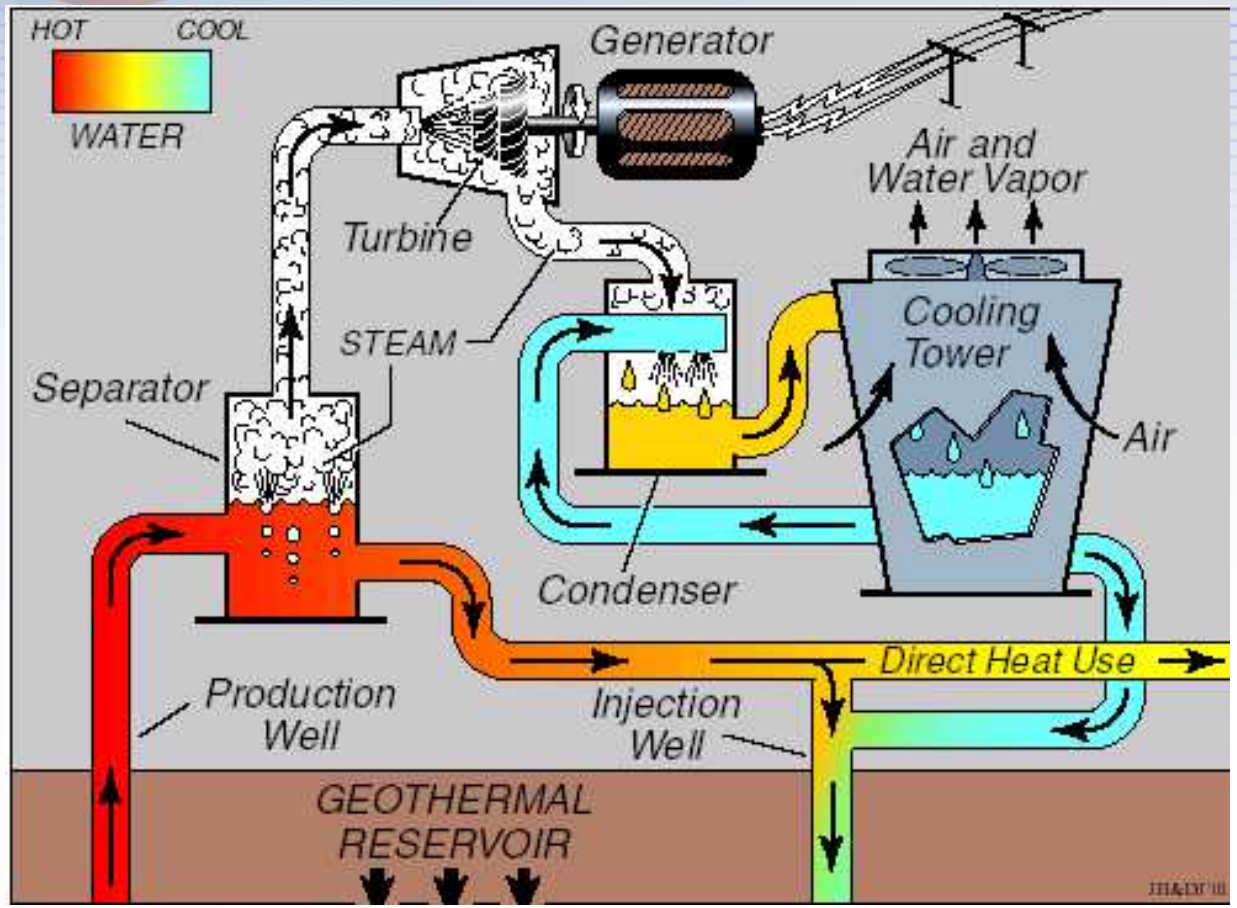
Dry Steam Power Plant



Courtesy of Geothermal Education Association

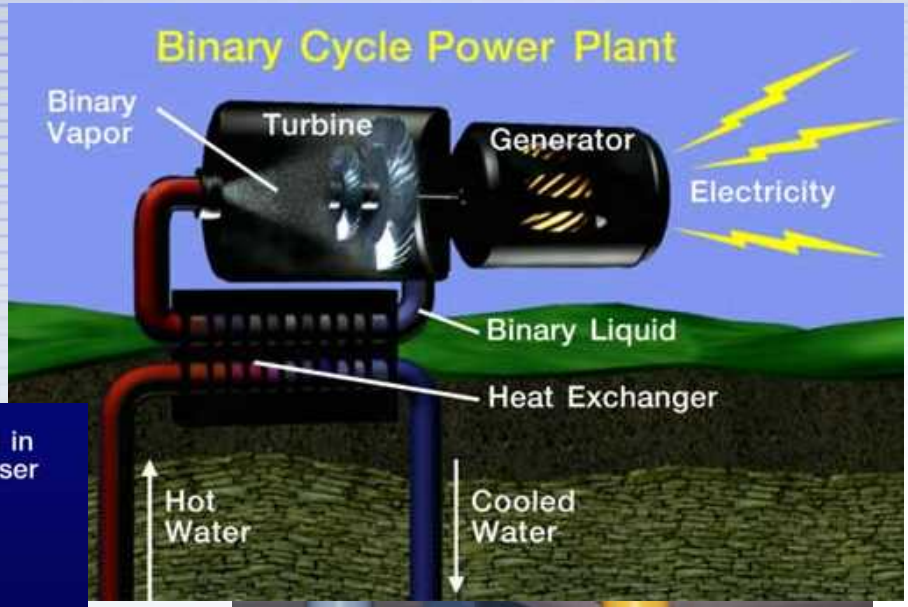
In dry steam power plants, the steam passes through a rock catcher (not shown) and then directly into the turbine. The steam spins the turbine blades, which spin the generator.

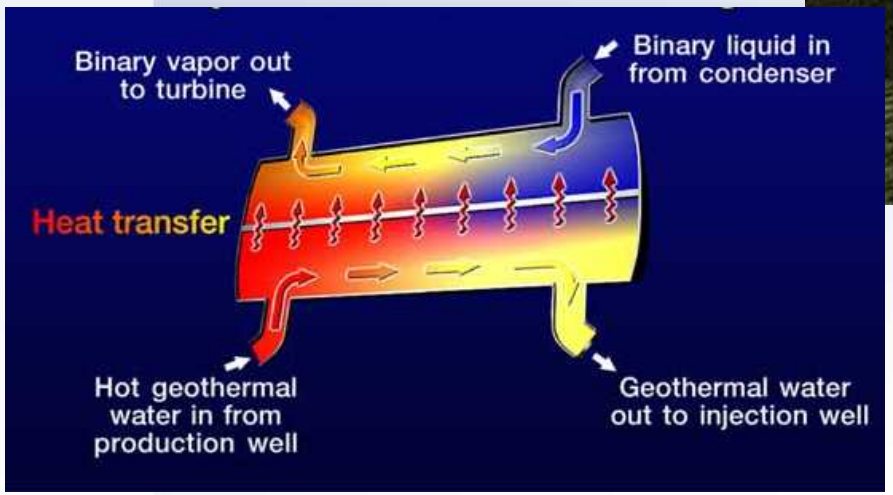
Geothermal Power Plant (flash)



Binary Cycle Geothermal Plant

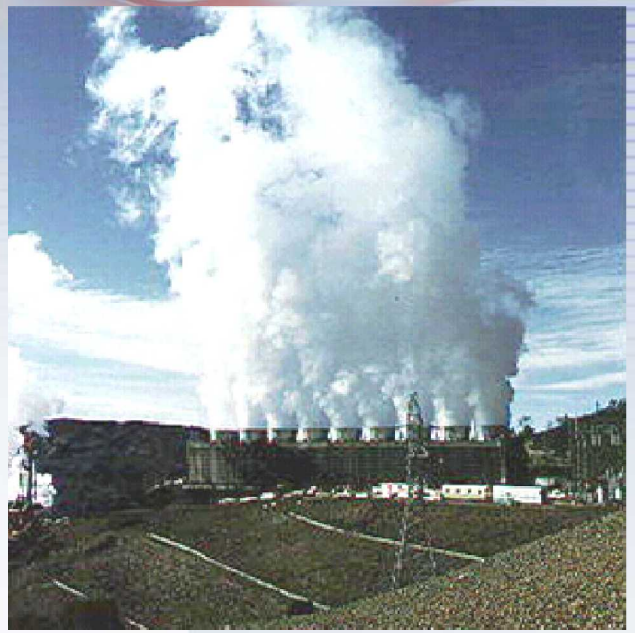
In a binary cycle plant, hot water is run through a heat exchanger to vaporize a working fluid that powers the turbine generator. The geothermal water is injected back into the reservoir.





This plate-type heat exchanger passes geothermal water over metal plates for heat transfer to the working fluid on the other side.

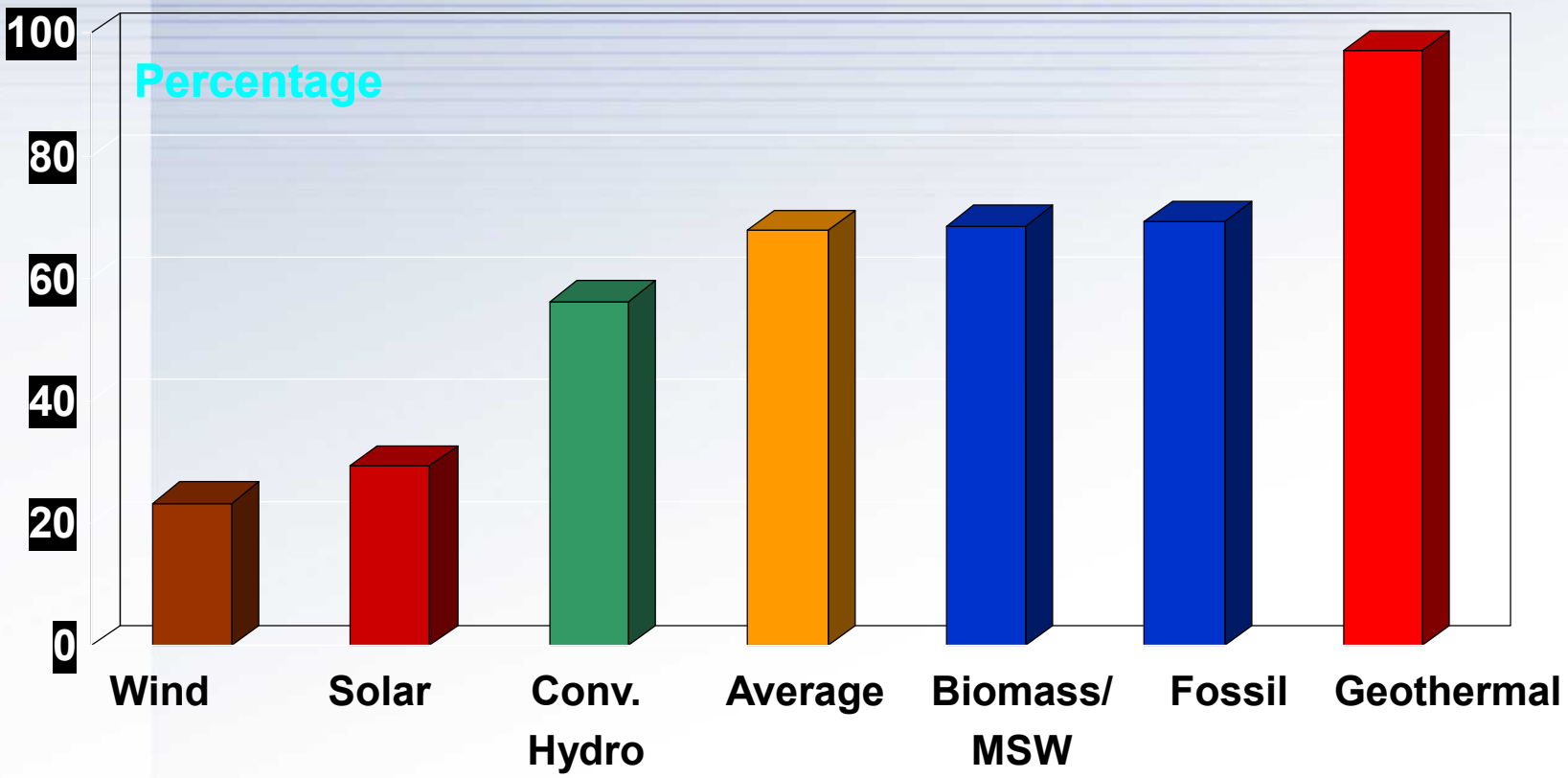
Significant Energy Production



Geothermal power plants produce a few % of California's electricity

This hybrid binary/flash power plant provides electricity on the Big Island of Hawaii

Capacity Factors



Source: DOE/Energy Information Agency

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Challenges to Geothermal Development

- Competition with fossil fuels
- Financing
- Long project lead times
- Siting and Permitting
- Obvious sites already taken
- Industry focus overseas
- Large projects at high costs
- Exploration cost and risk

Geothermal Energy

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GeoPowering the West

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