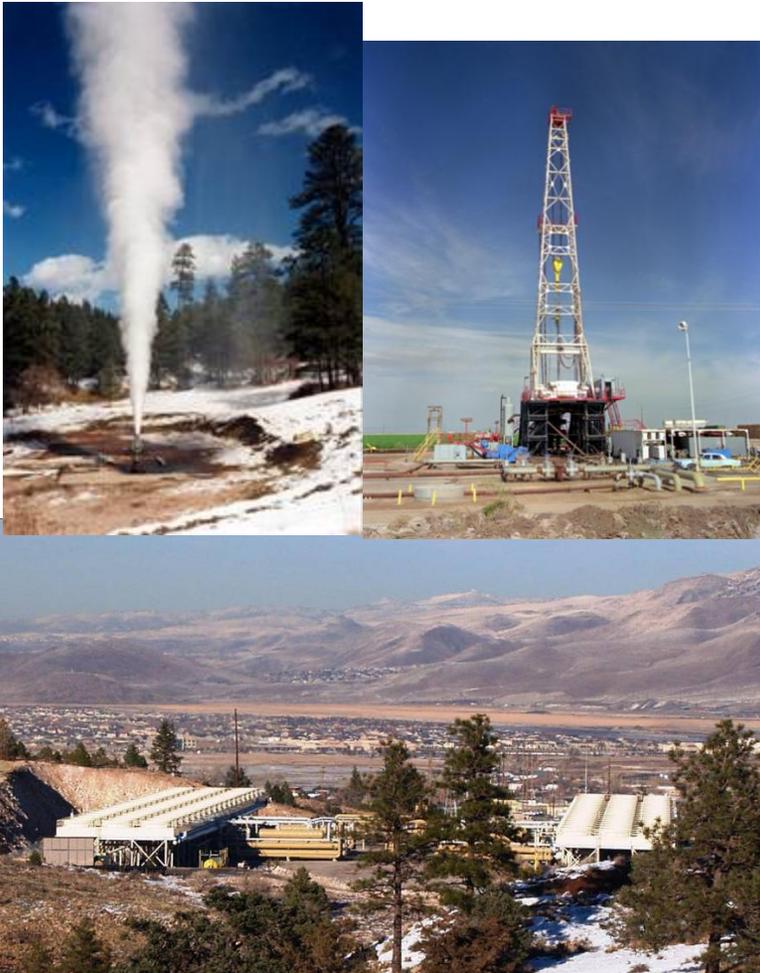




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Energy Efficiency and Renewable Energy



# Geothermal Energy Technology

Presentation to  
STEAB

Allan Jelacic  
Acting Program Manager  
March 15, 2007



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Energy Efficiency and Renewable Energy

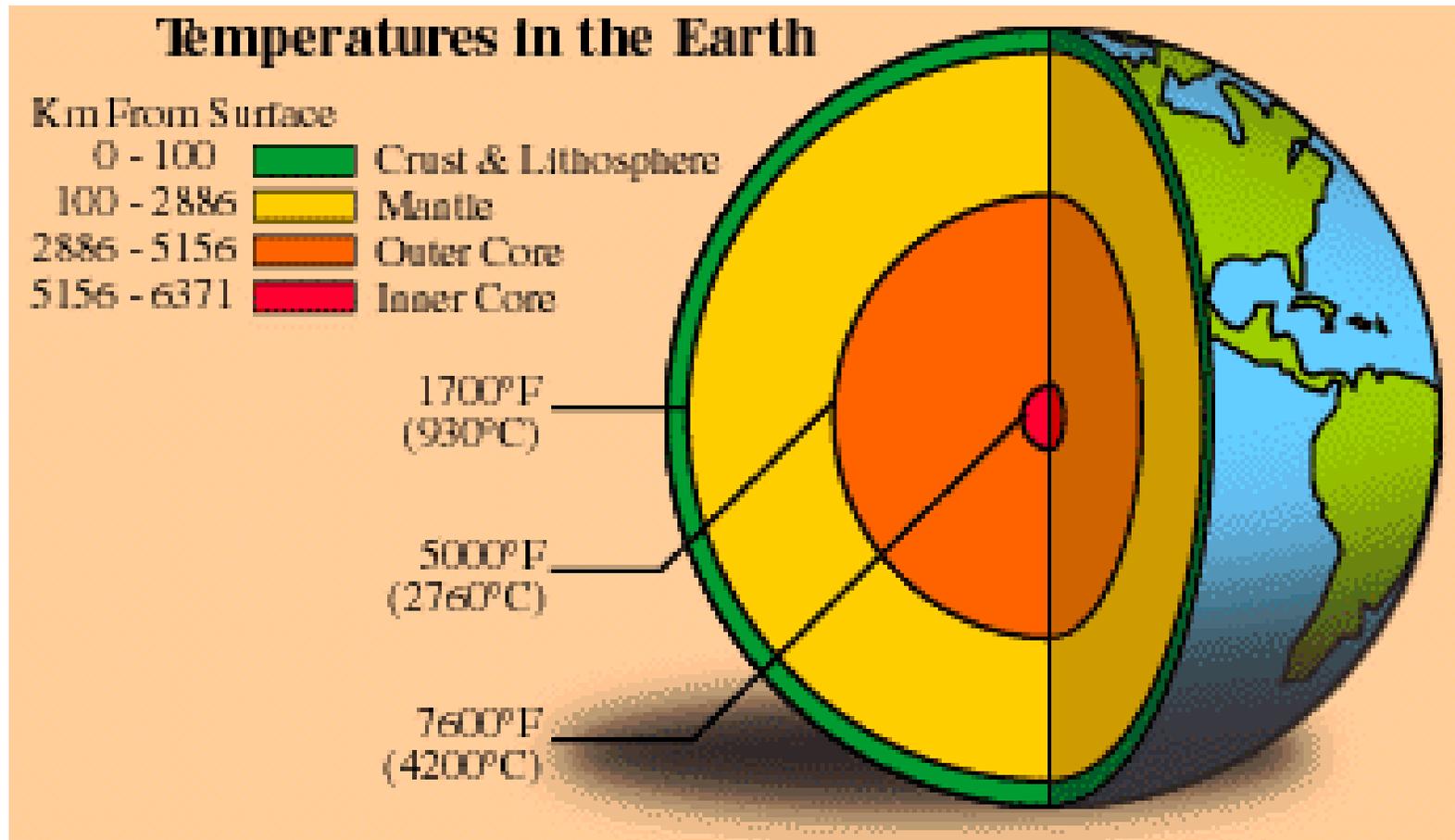
# Briefing Outline

- The Geothermal Resource
- Applications
- Market Barriers
- Outlook



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# Earth is Hot!

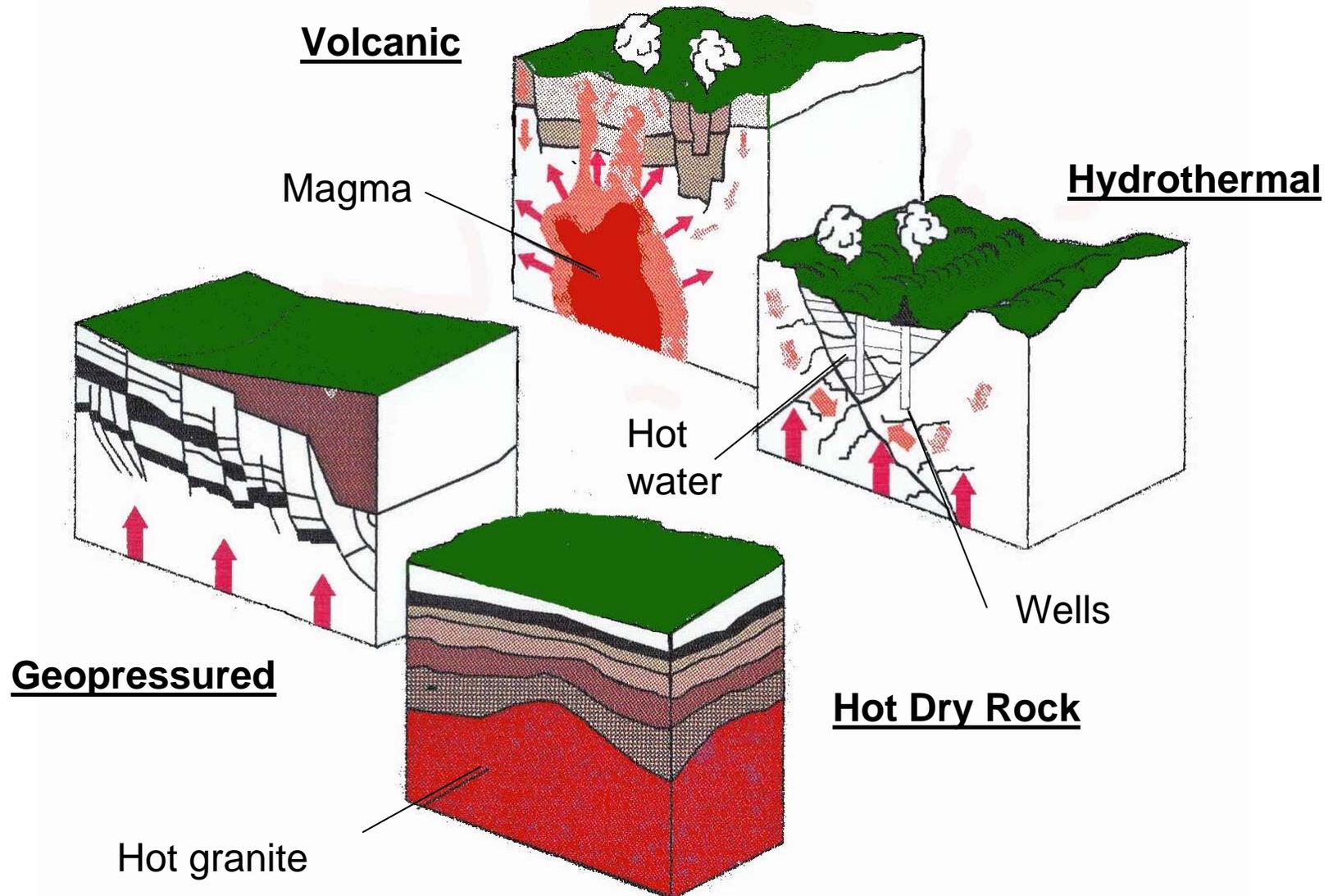


99% greater than 1000°C



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# Geothermal Resources

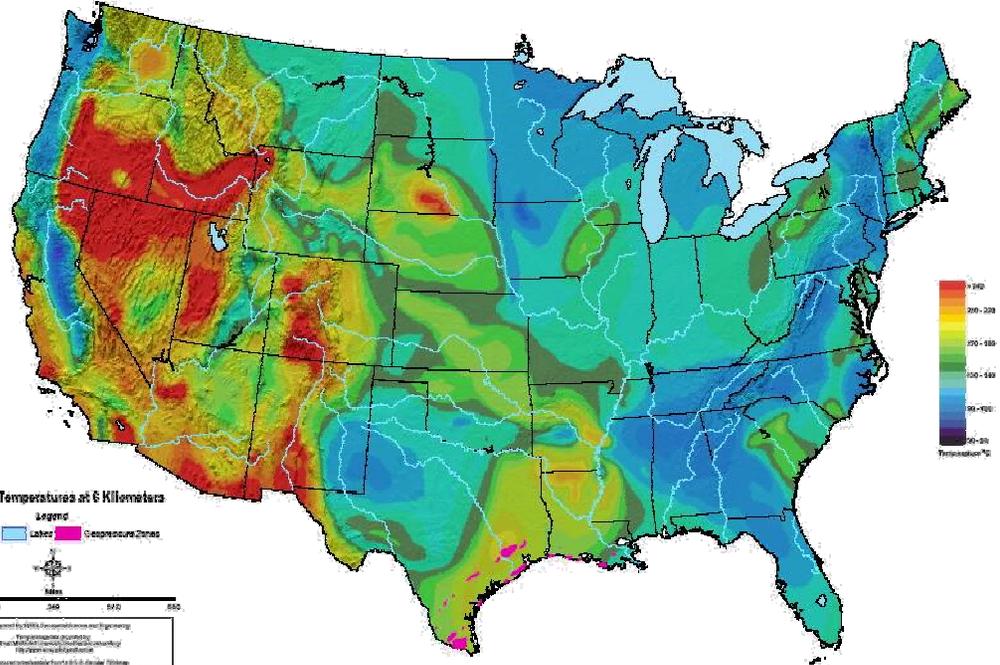
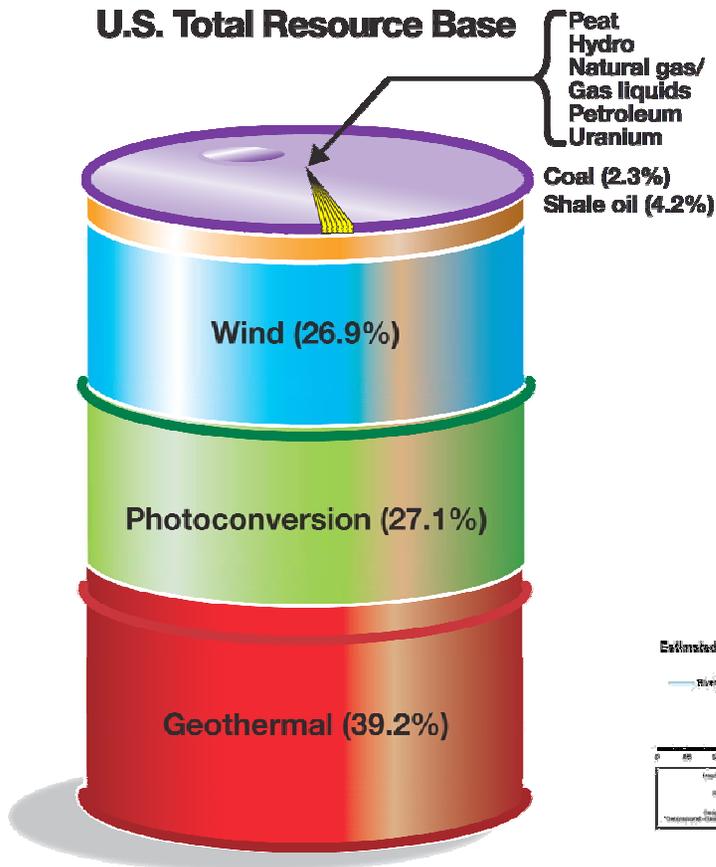




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# Domestic Resources

## U.S. Total Resource Base

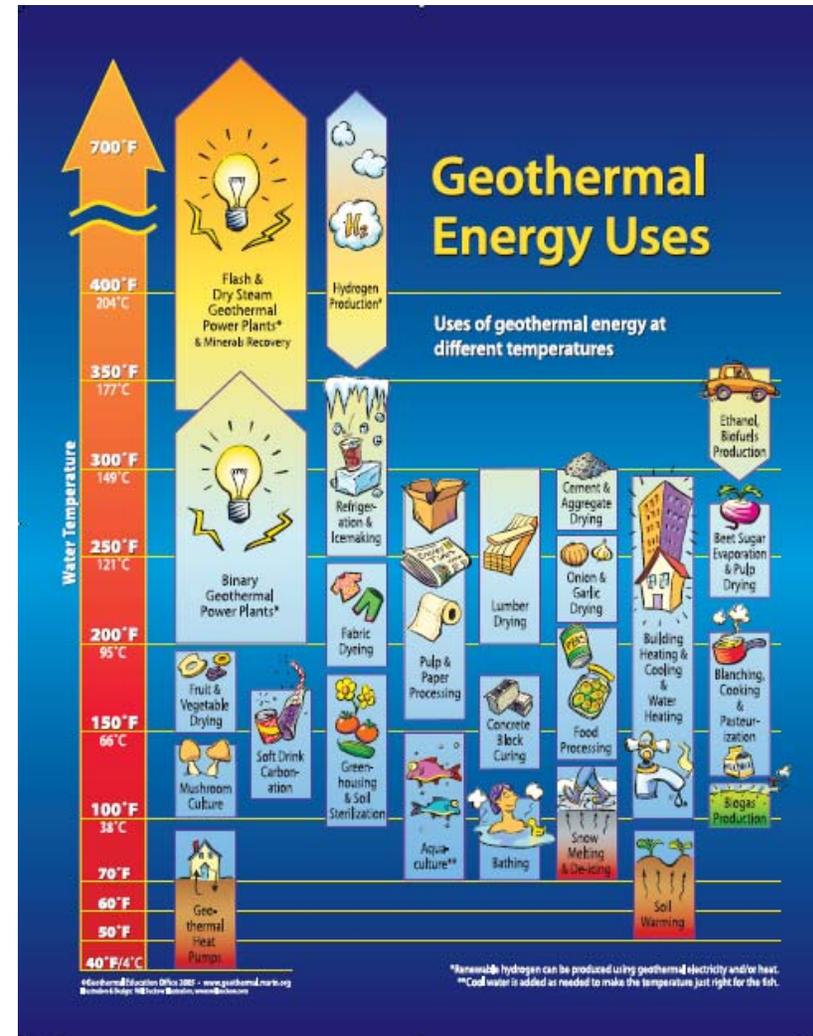




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# Geothermal Applications

- Electricity Generation
- Direct Uses
- Geothermal Heat Pumps

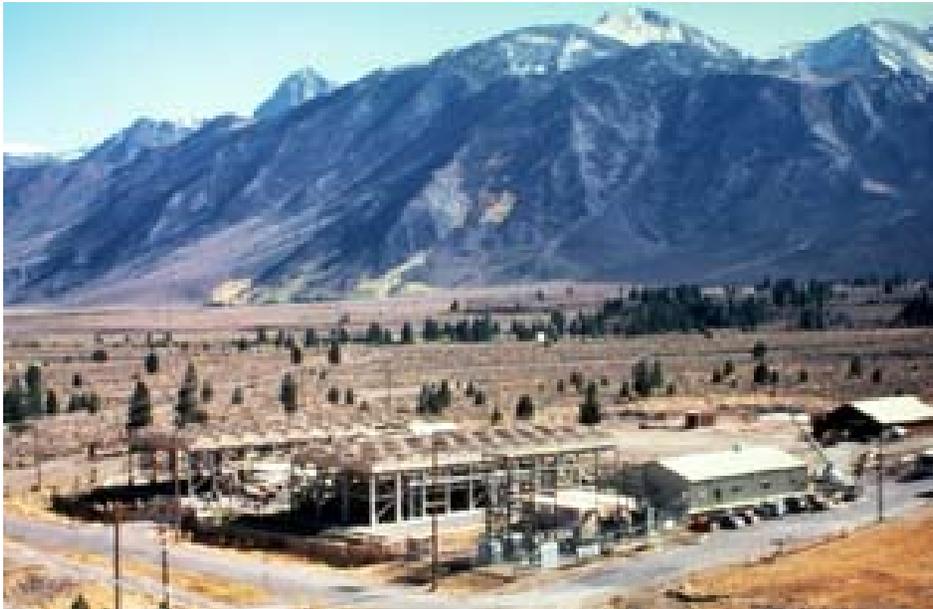


Graphic courtesy of the Geothermal Education Office



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# Hydrothermal Energy



- Hot water/steam from heated aquifers
- Widespread over Western United States
- Baseload power
- Capacity factor >90%
- Low or no emissions



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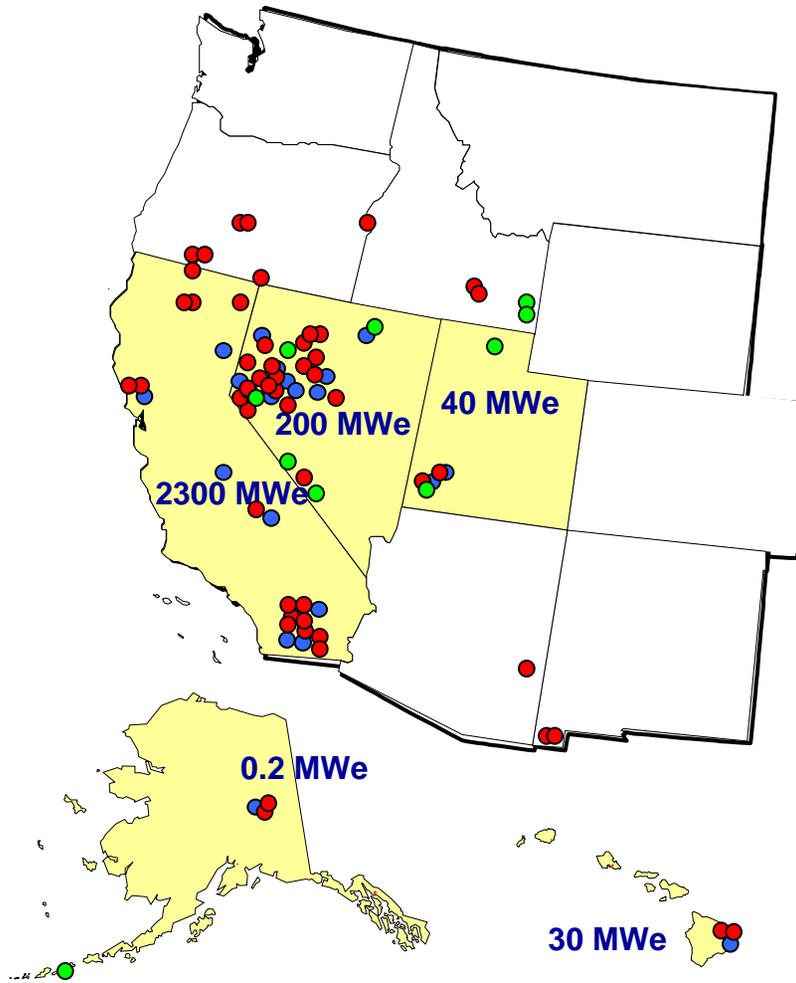
# History of Electric Power Development

- 1960: Commercial production began at The Geysers in California (11 megawatts)
- 1970s and 1980s: Rapid industry growth with Federal support
- 1990s: Industry focused on international markets
- 2000s: Renewed interest in domestic geothermal energy development due to increased domestic power prices, and federal and state incentives, primarily the federal production tax credit (PTC) and state renewable portfolio standards (RPS)



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# Generating Capacity



**Installed: 2600 MWe**

- Geothermal Plant
- Geothermal Plant Under Development
- Proposed Geothermal Plant



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# Near-Term Development Trends

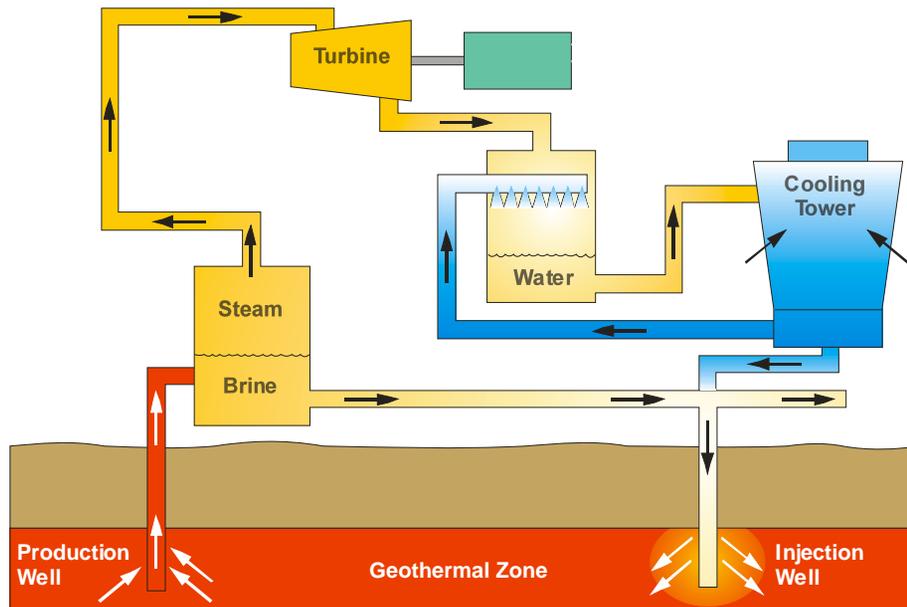
- Projects under active development total 957.7 MWe
- New projects in 9 states
- Western Governors' Association estimates potential for 5,630 MWe of new generation in 11 western states by 2015



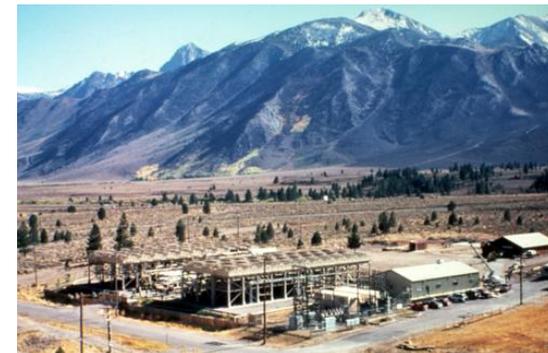
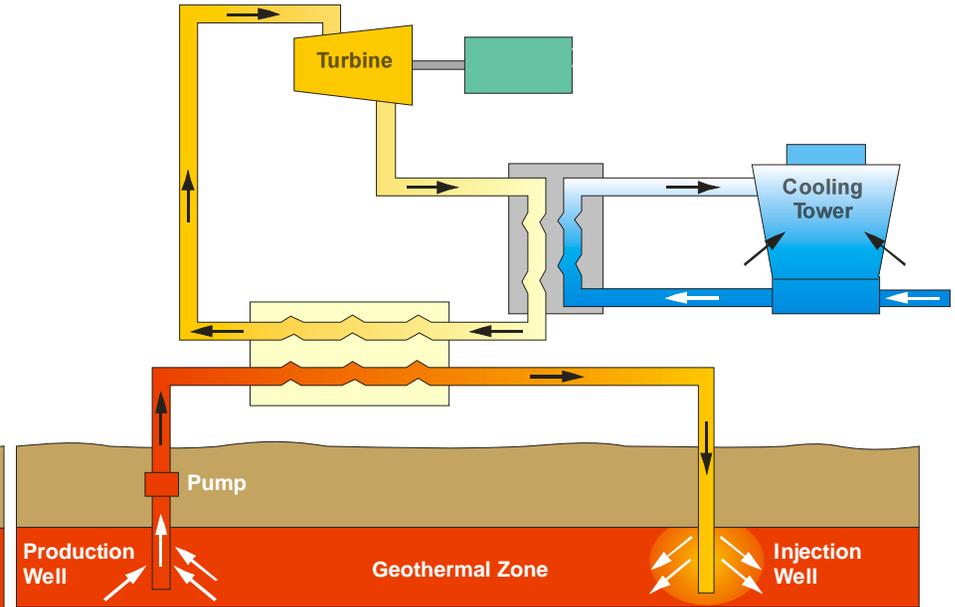
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# Power Plant Designs

## Steam Cycle



## Binary Cycle





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# A New Market Paradigm?



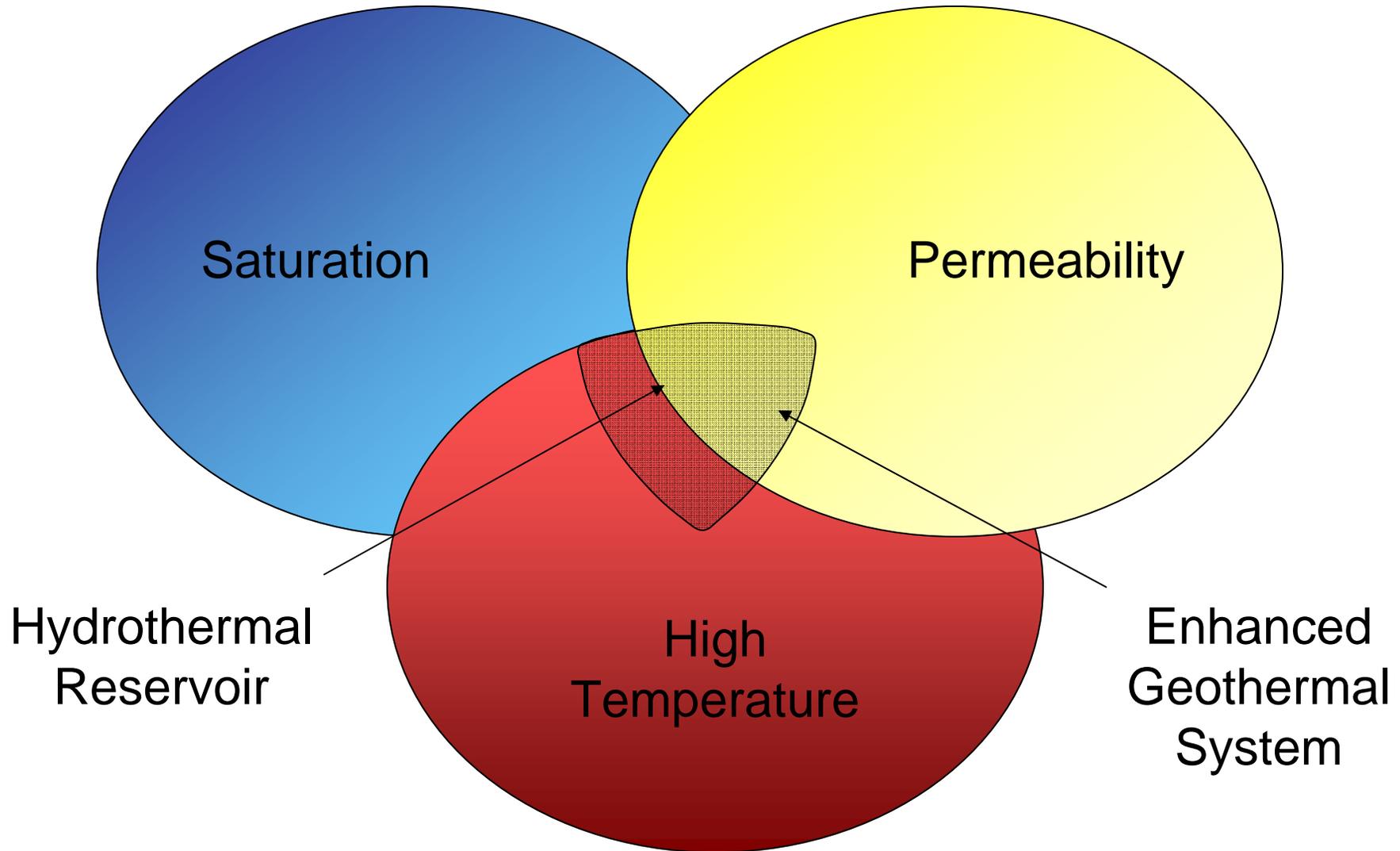
Demonstration of world's lowest temperature distributed energy geothermal power plant

- United Technologies and Chena Hot Springs resort demonstration project, August 2006
- Chena project selected "Project of the Year", by Power Engineering Magazine, November 2006
- Technology has multiple potential applications for low-temperature resources



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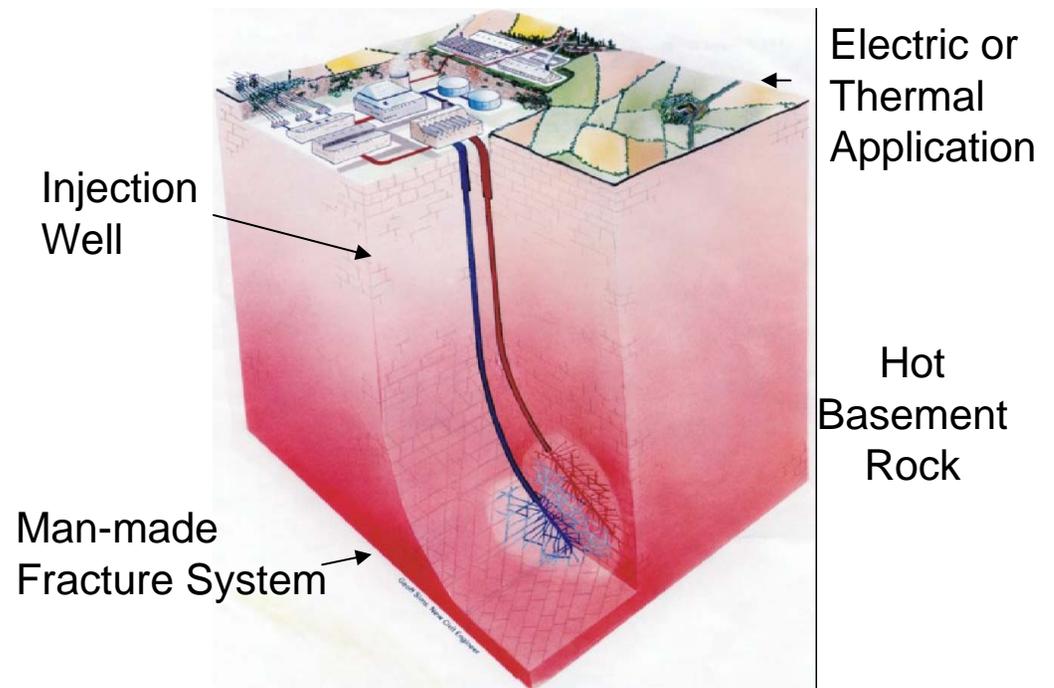
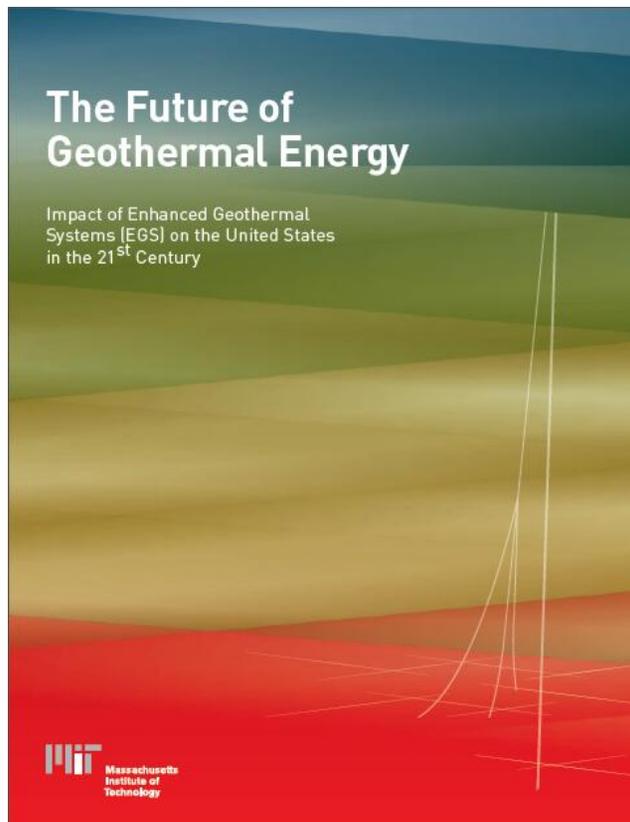
# Geothermal Domains





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# Enhanced Geothermal Systems (EGS)

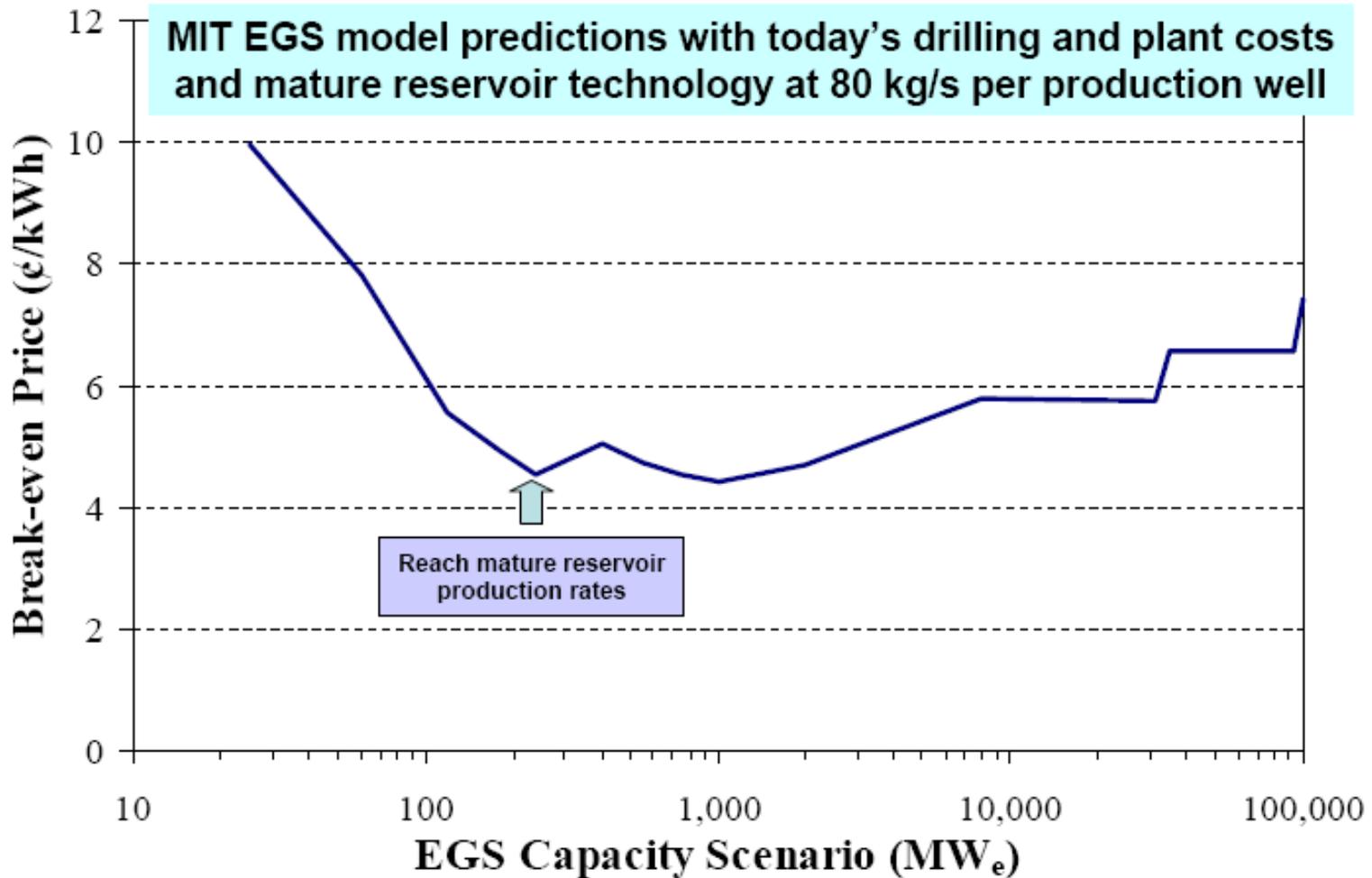


**EGS defined broadly as engineered reservoirs that have been stimulated to extract economical amounts of heat from unproductive geothermal resources.**



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# EGS Supply Curve

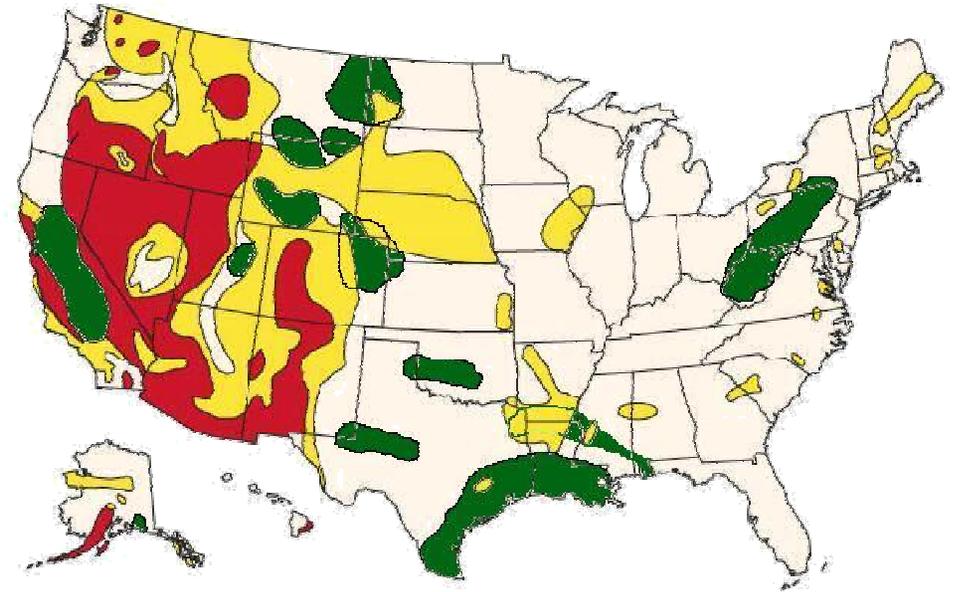




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# Geopressured Resources

- Coproduction of geothermal power and natural gas
- Best opportunities in Texas/Louisiana
- Rising gas prices may make generation economic



Geothermal Resources

■ Good - Excellent  
■ Fair - Moderate

■ Geopressure



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# Direct Use Applications

Direct use displaces about 1.6M barrels of oil annually in the United States.

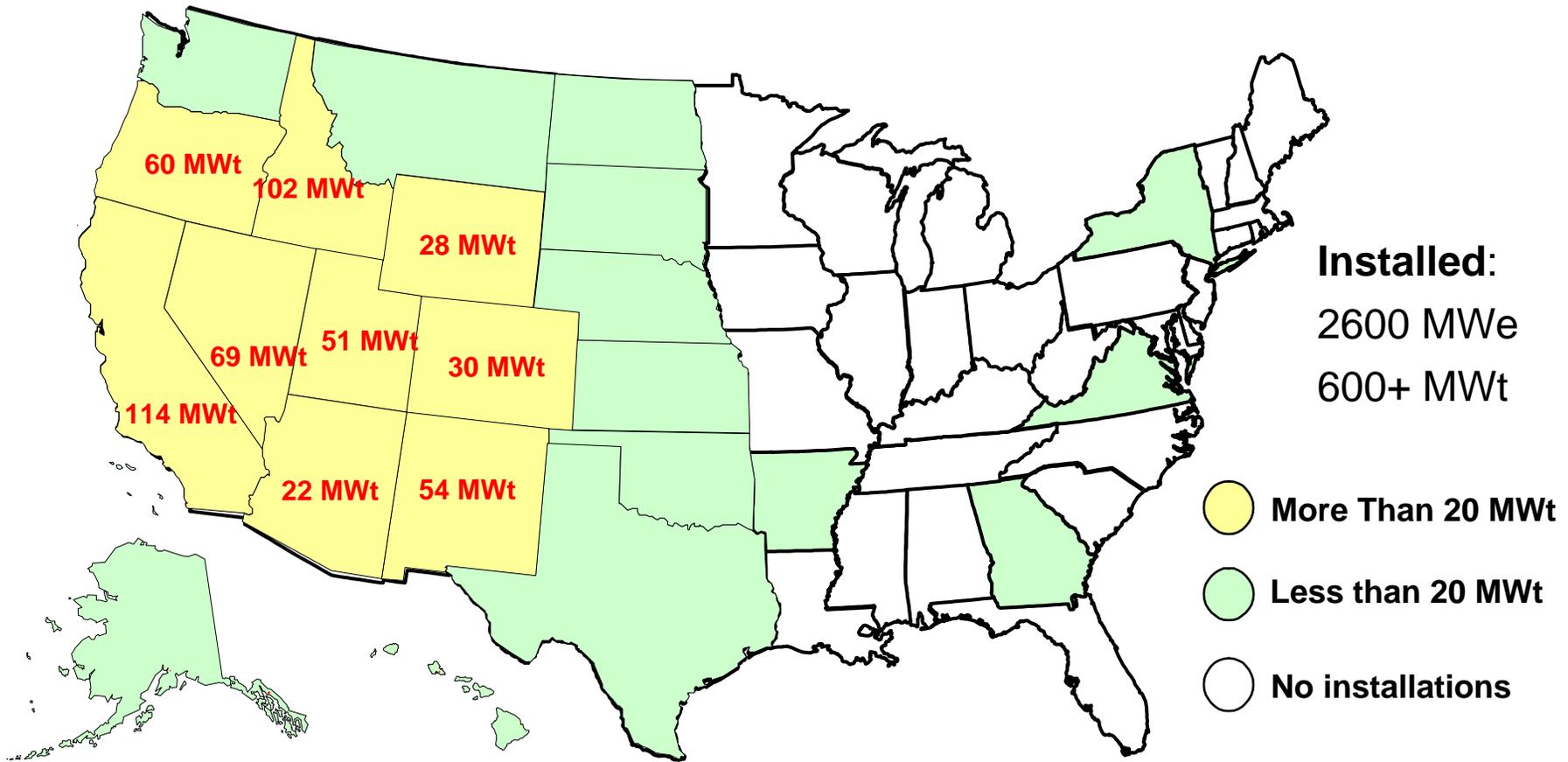
- District Heating
- Process Heat
- Agriculture
- Aquaculture
- Balneology (hot spring and water bathing)





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# Direct Use Installations

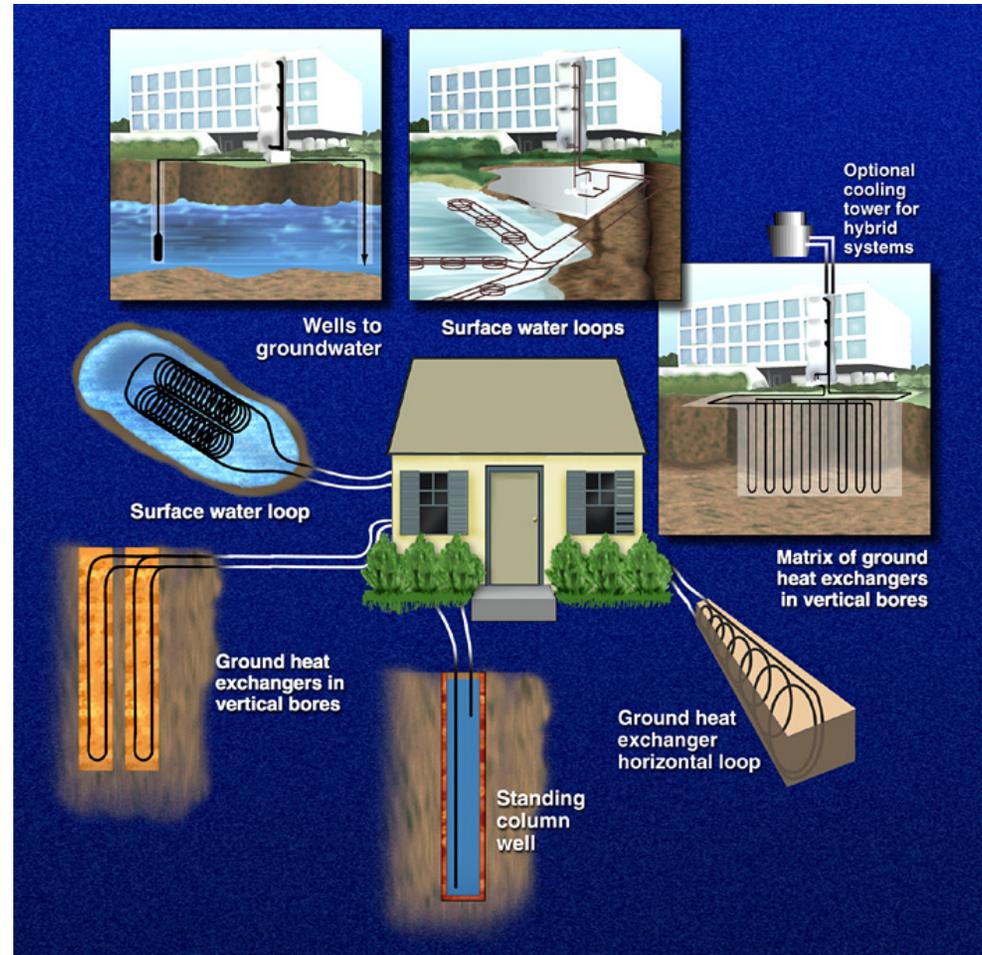




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# Geothermal Heat Pumps

- Earth serves as heat source in winter, heat sink in the summer
- Fluid circulates through underground piping; system extracts energy from the earth for heating, or adds energy for cooling
- Among the most efficient heating and cooling technologies available
- 800,000 to 1 million geothermal ground source heat pumps now in use throughout the United States
- Replaces both furnace and air conditioner
- EPA endorsement





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# Heat Pump Systems

- Higher installation cost than conventional systems, but energy savings pay off within 5 years
- Energy Policy Act of 2005 provides up to \$300 in tax credits for homeowners for certain heat pump systems
- 22 states offer GHP tax incentives





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# Geothermal Energy For Heat and Power

## Domestic Benefits

- \$2.0 billion domestic annual electricity sales (~13,000 MWh electric; ~0.3 quadrillion Btu total)
- Baseline power – 90%+ capacity factor
- Costs 5 to 8 cents/kWh
- 6% of California electricity generation, 10% northern Nevada, 25% island of Hawaii
- Over \$600 million in cumulative royalties to Federal government
- Four million electric utility customers served annually
- 2,507,000 MWh annual direct energy usage
- 6,170,000 MWh annual geothermal heat pump usage



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# Market Barriers

- Leasing and Permitting Process
- Investment Risk/Front End Cost
- Perception of Environmental Impacts
- Transmission Access
- Resource Confirmation Risk



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# Federal Role

- Policy Support
- Resource Assessment
- Regulations
- Research and Development

# Geothermal - An Enabling Energy Source

DOE can work with U.S. industry to make all this happen via the Geothermal Technologies Program

## Multiple Uses



Heat Pumps  
Electricity Generation  
Direct Thermal Uses  
Produce Strategic Materials

## Hydrogen Economy



An Energy Source to Drive the  
Hydrogen Economy, Base Load  
Renewable Energy

## Energy Security



A Domestic Source

**Geothermal  
Energy—A Key to  
Our Future**

## Widespread Resource



Across the U.S. and World

## Economic Development



Job Growth Rural Development  
Projects for Disadvantaged Minorities

## Environmentally Friendly



No Carbon Emissions