GeoPowering the West

(Initiative)

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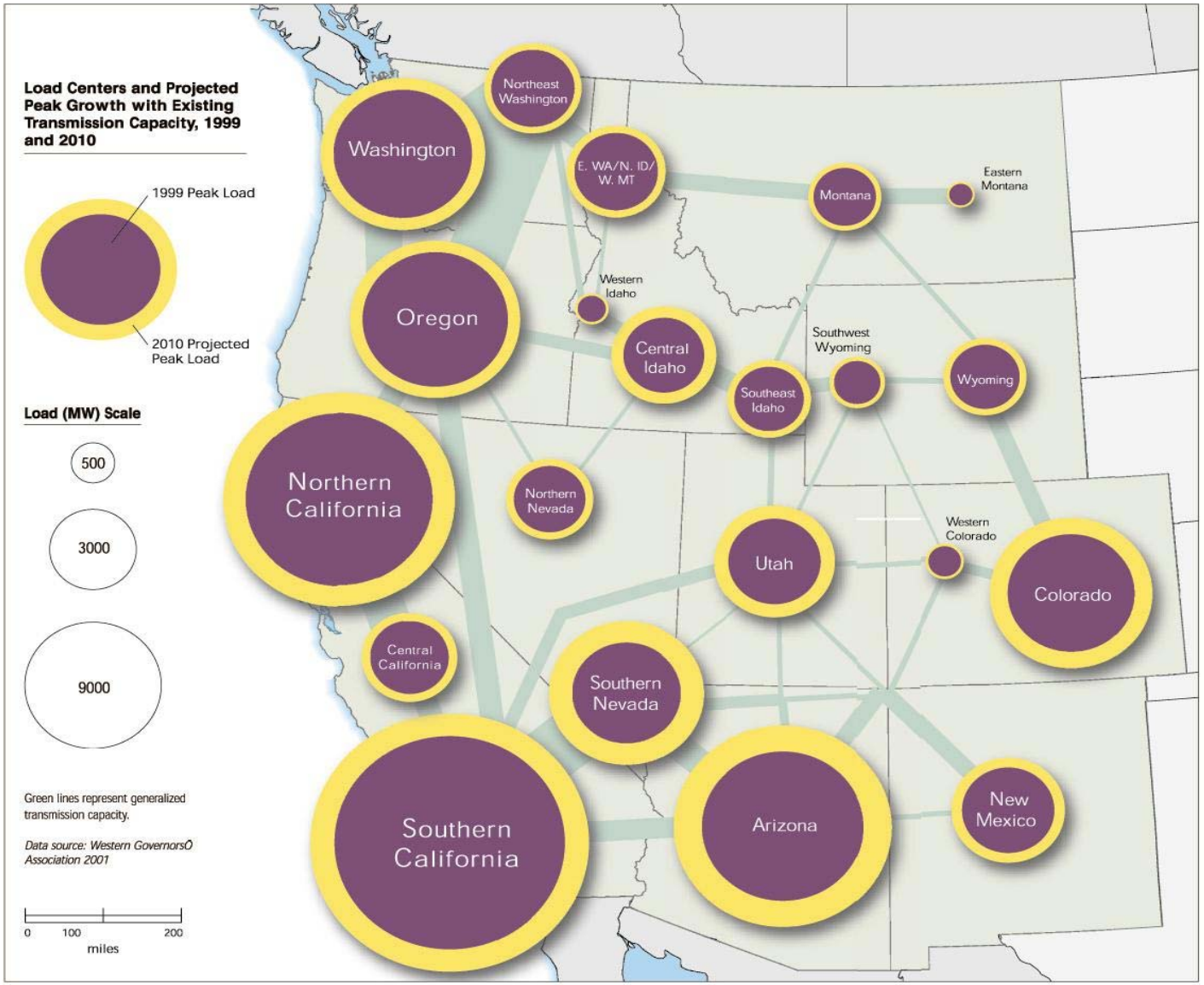
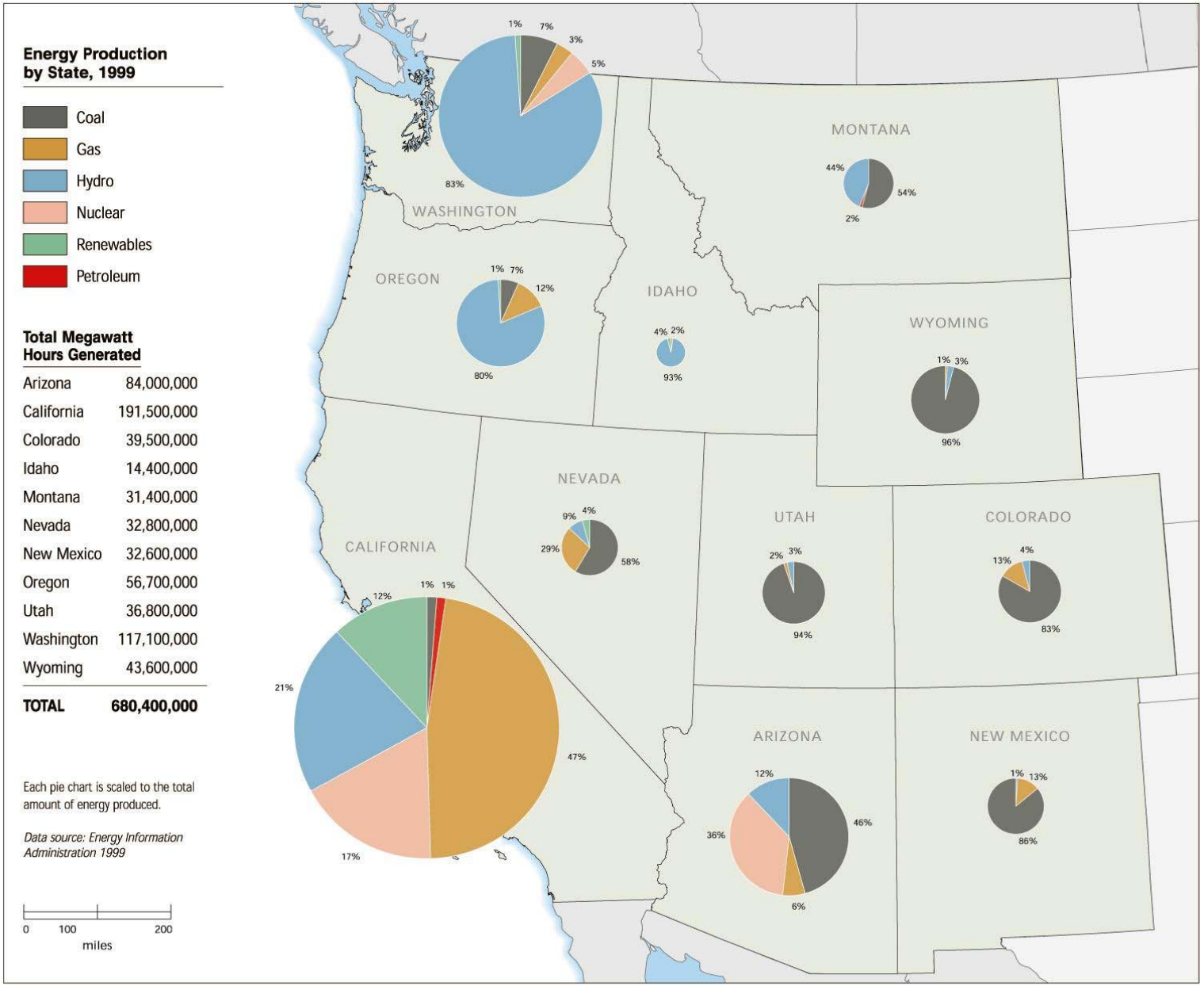
Western US: Load Growth



Source: Renewable Energy Atlas

Electricity Generation

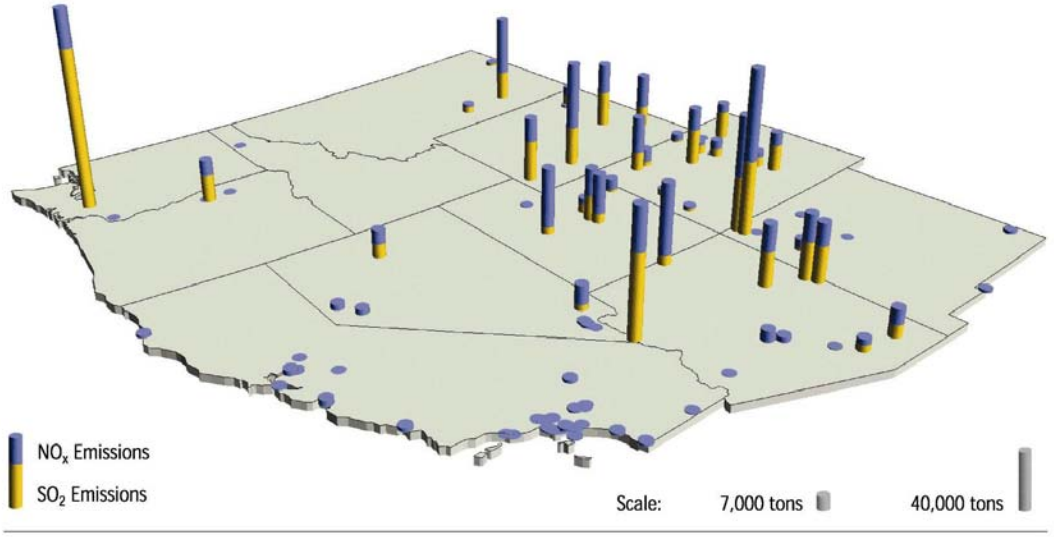


Source: Renewable Energy Atlas

Regional Power Plant Emissions

Power Plant Emissions, 2000

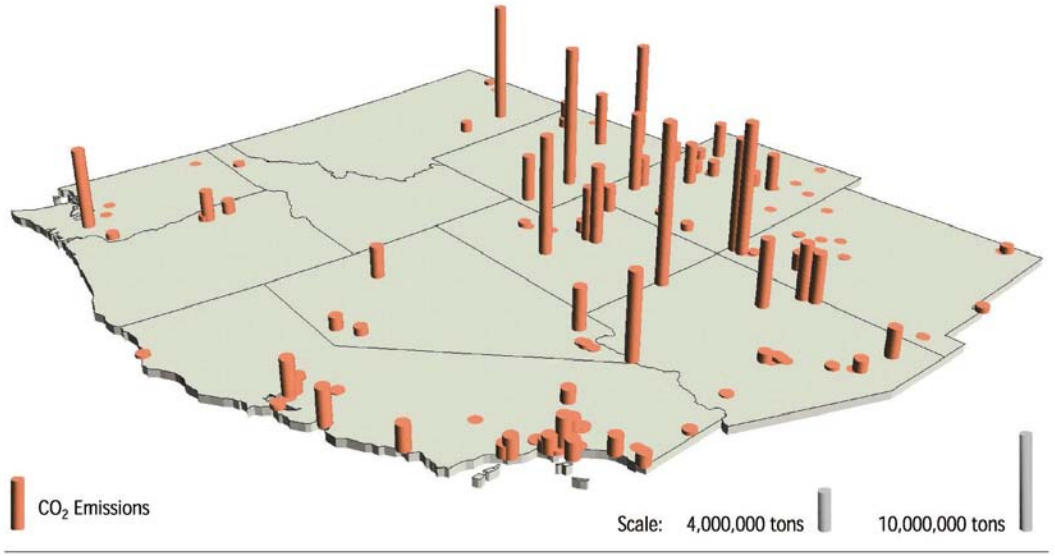
Each bar represents the location of a power plant regulated under the EPA® Acid Rain Program (Title IV). The height of the bars is scaled to reßect the emissions levels for each plant. Because CO_2 emissions are so much higher than either SO_2 or NO_x, different scaling factors were used to determine the height of the bars.



Total Emissions in Region from Title IV Plants, 2000

	tons
Sulfur Dioxide (SO_2)	506,662
Nitrogen Oxide (NO_X)	547,754
Carbon Dioxide (CO_2)	316,774,136

Data source: EPA Acid Rain Program (Title IV) Emissions Scorecard, 2000



Source:
Renewable Energy Atlas

GeoPowering the West Approach

National Energy Situation: Volatile electricity and fuel markets
Priorities: Cost stability, efficiency, sufficiency, and sustainability
Significant opportunities for geothermal power production/heat use

Users, customers (market pull) requirements

GPW info, Technical Assistance

Technology Advancement and Deployment

Resource Exploration and Confirmation

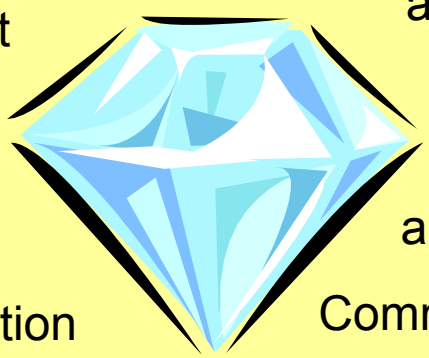
Policy Issues

Education and Outreach

Communications

Federal Aggregation

Institutional Improvements



Geothermal Systems

Geothermal R&D Program

Technology (technology push)

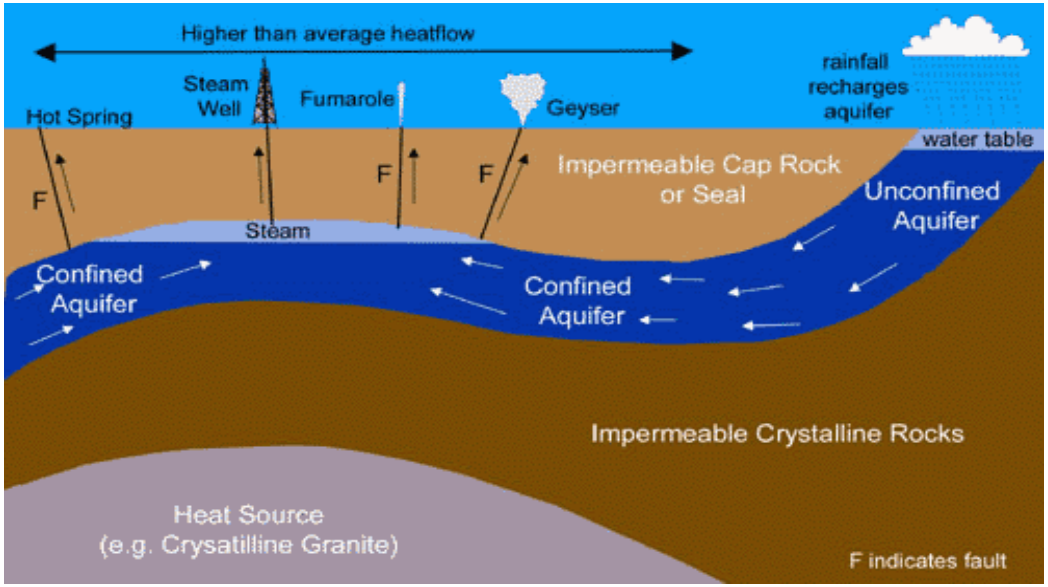
Significant Energy Production

Geothermal power plants produce almost 5% of California's electricity (12.8 million MWh in 1999)

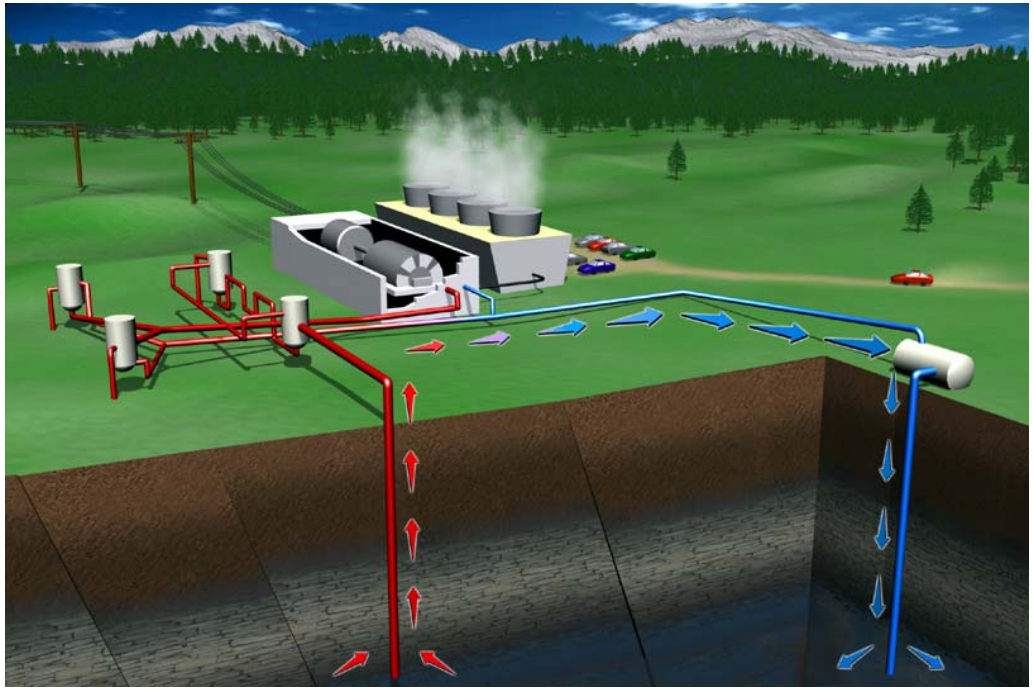
This hybrid binary/flash power plant provides about 25% of electricity demand on the Big Island of Hawaii

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.



Geothermal Applications



Courtesy of Geothermal Education Association

Electricity Generation

- Central Station Power
- Distributed Power

Mineral Recovery

- Zinc
- Silica

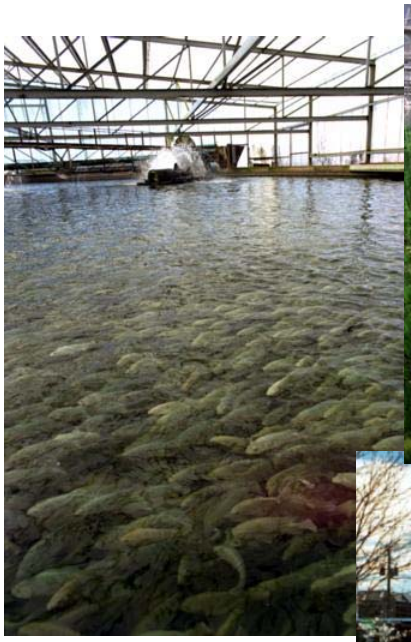
Heat Production

- District Heating
- Industrial Process Heat
- Agriculture
- Aquaculture

Direct Use Applications

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

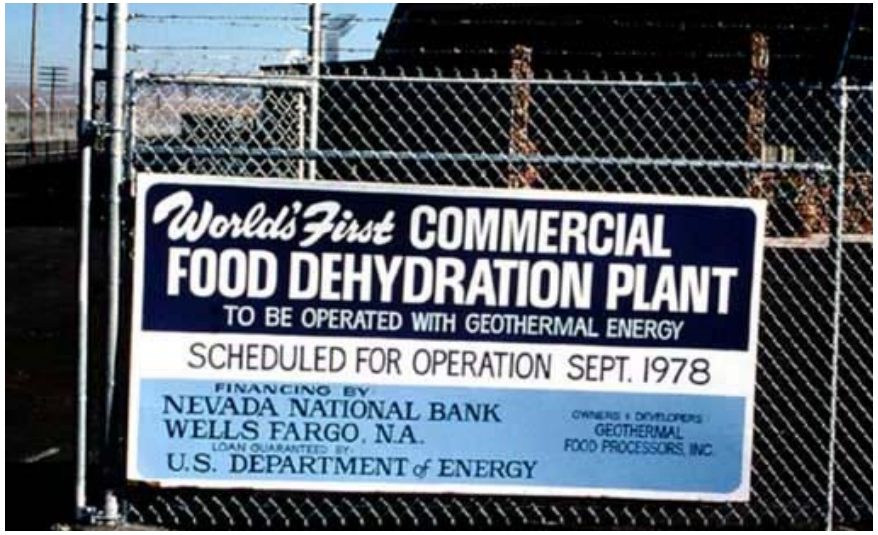
- District Heating
- Process Heat
- Agriculture
- Aquaculture
- Balneology (hot spring and water bathing)



Greenhouses such as this one in New Mexico can be heated with geothermal water. Plants grow faster and larger when they have additional heat.

A prawn grown in geothermally heated water at the GeoHeat Center, Oregon Institute of Technology.

Geothermal energy is also used for industrial drying. This plant in Brady, Nevada, provides dried onions to Burger King.



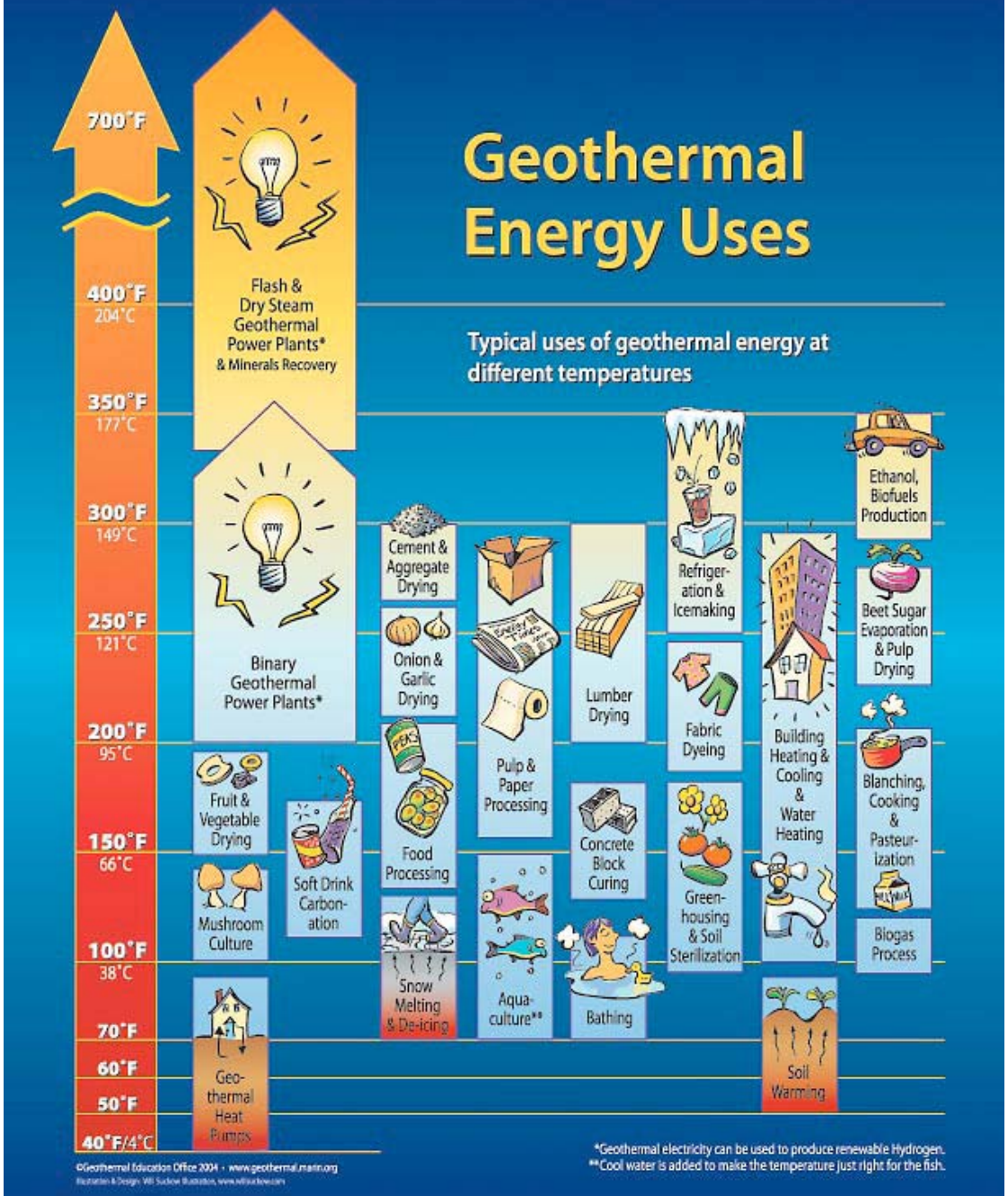

Geothermal Energy Uses
Typical uses of geothermal energy at different temperatures
700˚F
400˚F
204˚C
350˚F
177˚C
300˚F
149˚C
250˚F
121˚C
200˚F
95˚C
150˚F
66˚C
100˚F
38˚C
70˚F
60˚F
50˚F
40˚F/4˚C
Flash & Dry Steam Geothermal Power Plants* & Minerals Recovery
Binary Geothermal Power Plants*
Fruit & Vegetable Drying
Mushroom Culture
Soft Drink Carbon-ation
Geo-thermal Heat Pumps
Cement & Aggregate Drying
Onion & Garlic Drying
Food Processing
Snow Melting & De-icing
Pulp & Paper Processing
Aqua-culture**
Lumber Drying
Concrete Block Curing
Bathing
Refriger-ation & Icemaking
Fabric Dyeing
Green-housing & Soil Sterilization
Building Heating & Cooling & Water Heating
Soil Warming
Ethanol, Biofuels Production
Beet Sugar Evaporation & Pulp Drying
Blanching, Cooking & Pasteur-ization
Biogas Process
*Geothermal electricity can be used to produce renewable Hydrogen.
**Cool water is added to make the temperature just right for the fish.
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Illustration & Design: Will Sudow Illustration, www.willsudow.com

GeoPowering the West

California Collocated Resources

The California low-temperature database lists 989 thermal wells and springs.

These resources occur in volcanic terranes in northern California, in the Basin and Range Province in the northeastern part of the state, within the Long Valley caldera, and along faults in the sedimentary basins in southern California.

56 communities that are located within 8 km of a geothermal resource that has a reported temperature greater than 50°C.

The total population collocated with these resources exceeds 2 million people, thus the potential for expanded direct use in the near term is great.

Source: GeoHeat Center http://geoheat.oit.edu/califor.htm

California Collocated Resources

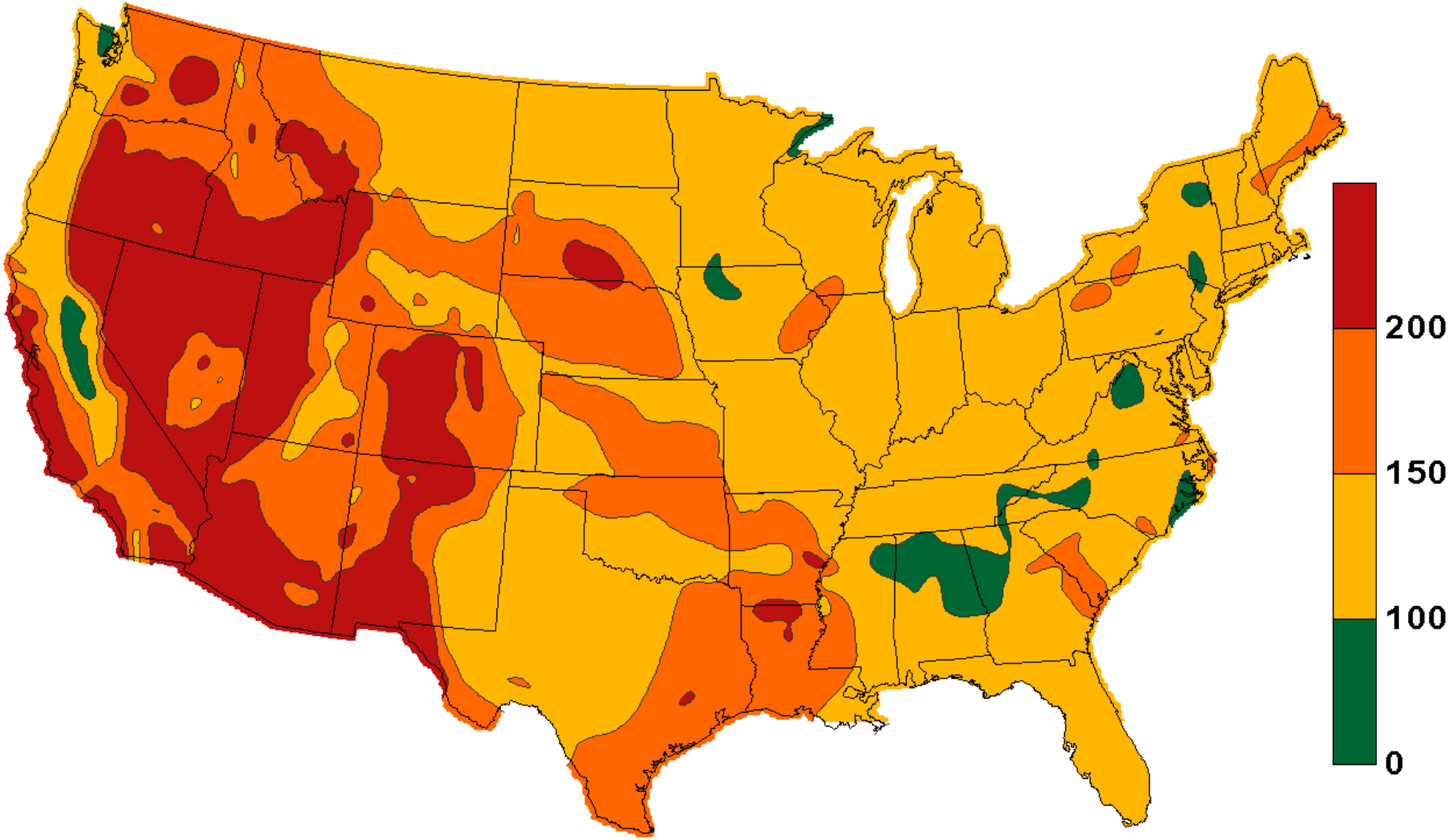
Markleeville 149°F
Wilbur Springs 347°F)
Byron 123.8°F
Bombay Beach 190.4°F
Brawley 280.4°F
Calexico 334.4°F
Calipatria 680°F
El Centro 334.4°F
Glamis 159.8°F
Heber 334.4°F
Holtville 399.2°F
Niland 658.4°F
Salton City 138.2°F
Westmorland 132.8°F
Bishop 136.4°F
Coso Junction 206.6°F

Johannesburg 204.8°F
Lake Isabella 129.2°F
Miracle Hot Springs 122°F
Randsburg 204.8°F
Clear Lake 368.8°F
Kelseyville 147°F
Lower Lake 368.6°F
Middletown / Cobb 212°F
Bieber 194°F
Litchfield 174.9°F
Susanville 174°F
Wendel 224.6°F
Encino 132.8°F
Alturas 187°F
Canby 240.8°F
Cedarville 208.4°F
Day 164.3°F

California Collocated Resources

Eagleville 132.8°F
Fort Bidwell 127.4°F
Lake City 320°F
Benton 134.6°F
Lee Vining 186.8°F
Mammoth Lakes 350.6°F
Tassajara Hot Springs 140°F
Calistoga 280.4°F
Costa Mesa 424.4°F
Newport Beach 424.4°F
Yorba Linda 163.4°F
Kings Beach 131°F
Drakesbad 264.2°F
Desert Hot Springs 199.4°F
Hemet 129.2°F
Lake Elsinore 129.2°F
Temecula 129.2°F
Widomar 129.2°F
Winchester 129.2°F
Colton 136.4°F
Highland 129.2°F
Red Mountain 204.8°F
San Bernardino 138°F
Trona 136.4°F
Twentynine Palms 145.4°F
San Diego 163.4°F
Warner Springs 132.8°F
San Luis Obispo 131°F
Gaviota 154.4°F
Montecito 132.8°F
Big Bend 179.6°F
Loyalton 201.2°F
Boyes Hot Springs / Sonoma 127.6°F
Ojai / Meiners Oaks 123.8°F

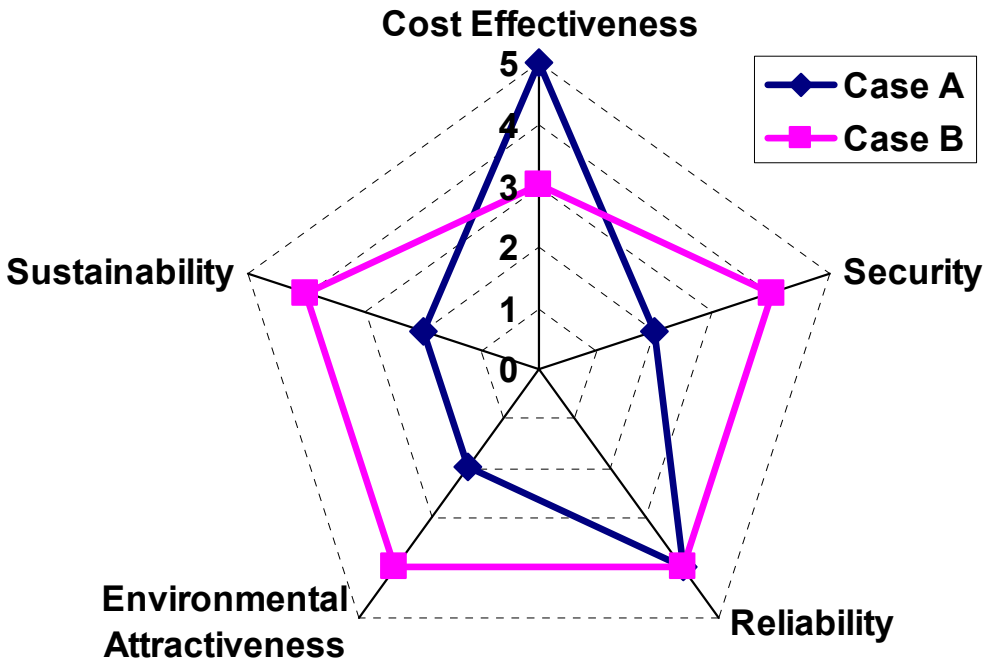
Source: GeoHeat Center http://geoheat.oit.edu/califor.htm



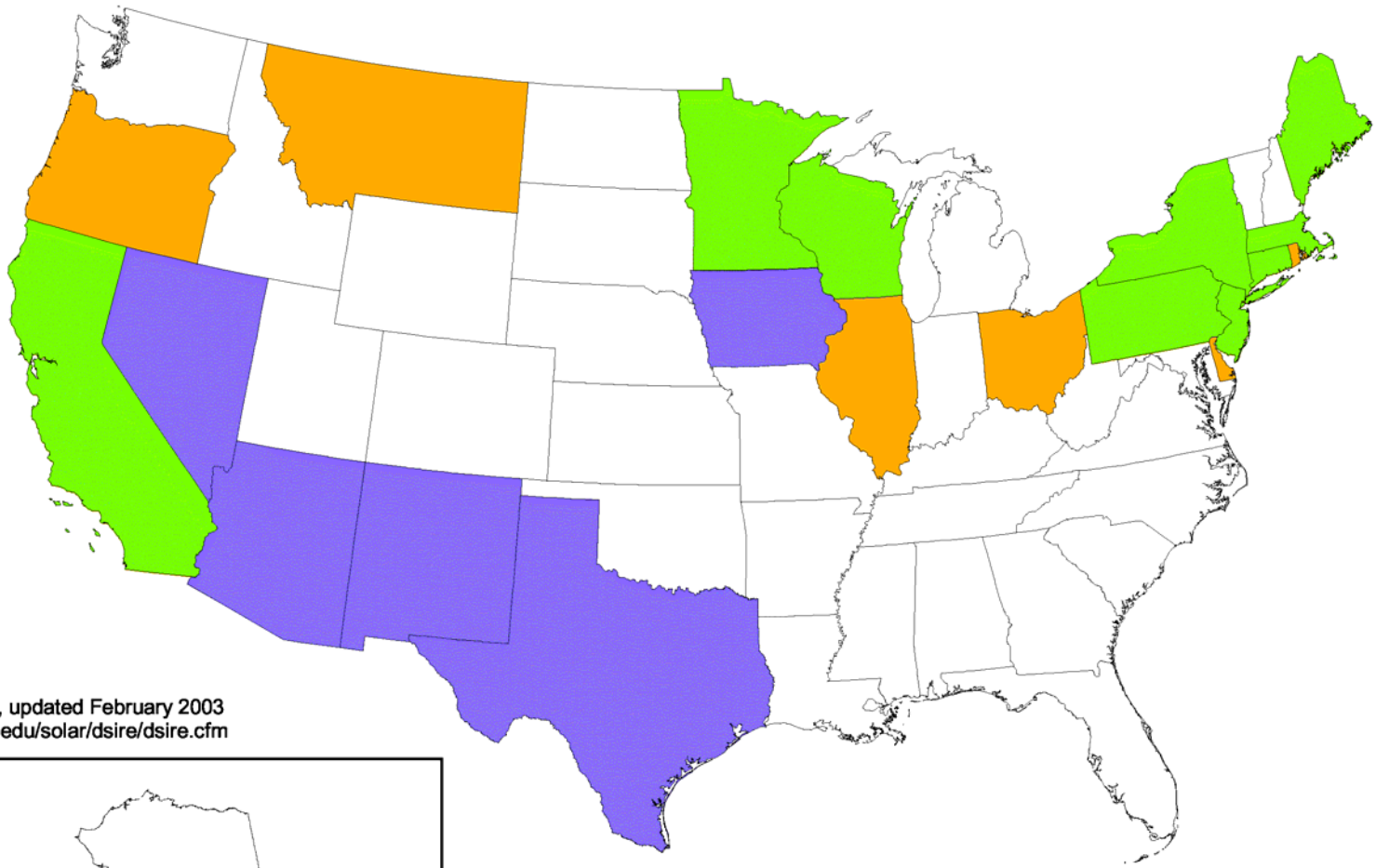
Estimated Earth Temperatures at 6 km Depth (°C)

Expected Trends in Future Energy System Evolution

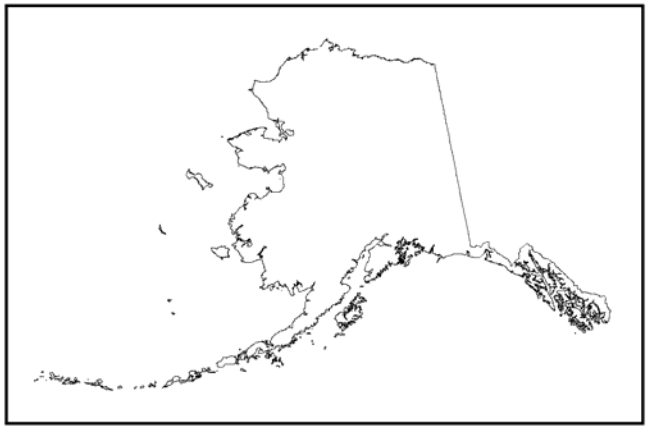
- Energy safety, security, reliability, and sustainability have become important energy system design parameters
- This will change how energy systems are optimized and upgraded
- This will impact future decisions on energy policy, supply, and use
- How do we efficiently and cost-effectively transition to this new future infrastructure?



United States - States with Renewable Energy Policies



Source: DSIRE, updated February 2003
www.dcs.ncsu.edu/solar/dsire/dsire.cfm



System Benefit Charges
Renewable Portfolio Standard
Both SBC and RPS

U.S. Department of Energy
National Renewable Energy Laboratory

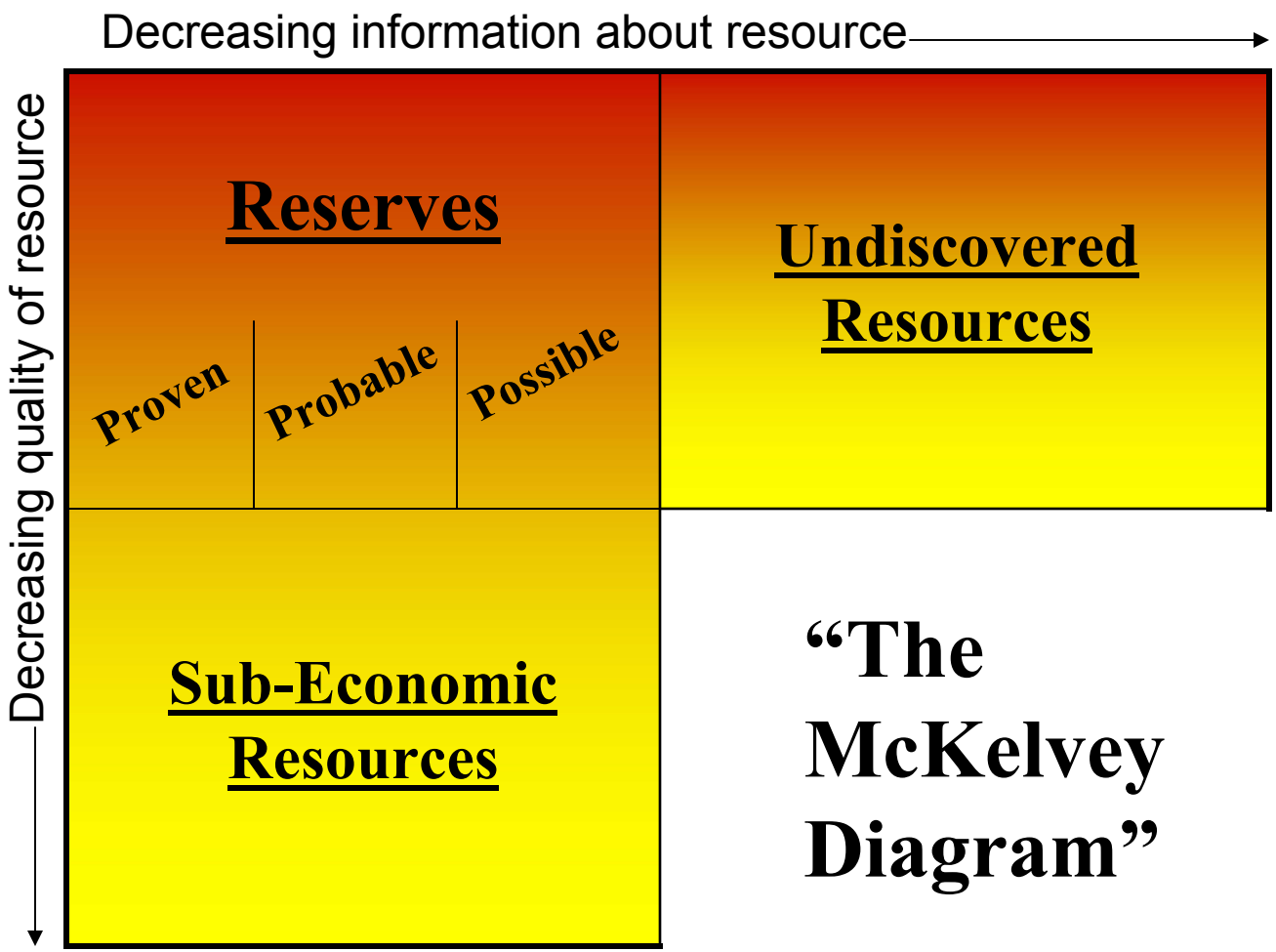
NREL

26-FEB-2003 1.1.19

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"

Steps to Determine Sites Suitable for Development

0. Must have a buyer
1. Need a good resource
2. Must have access to loads or grid
3. The land must be developable

A Vision for the Future

- Ready Access to Land
- Thoroughly Mapped and Developed Resources
- Cost Competitive Technology

GeoPowering the West