# Wind Energy

- ✓ The harnessing of the power of wind to turn turbines for electricity
- ✓ Also, wind power turned directly into mechanical energy such as a water pumping.


California


U.S.A.


West Texas


Antarctica


U.S.A.


Offshore Europe


Boeing 747-200
GE Wind Energy
3.6 MW Prototype
Turbine in Spain

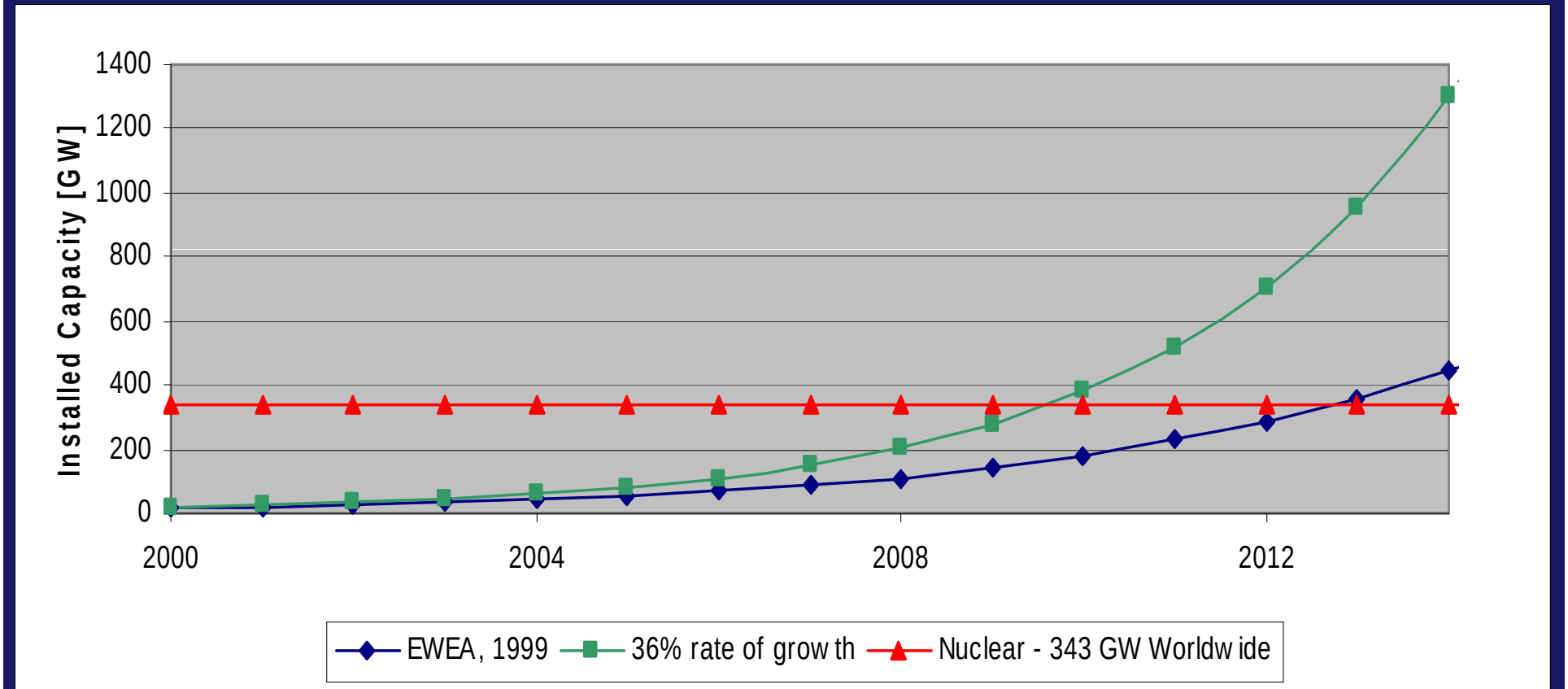
✓ Wind farms send their electricity to nearby substations.

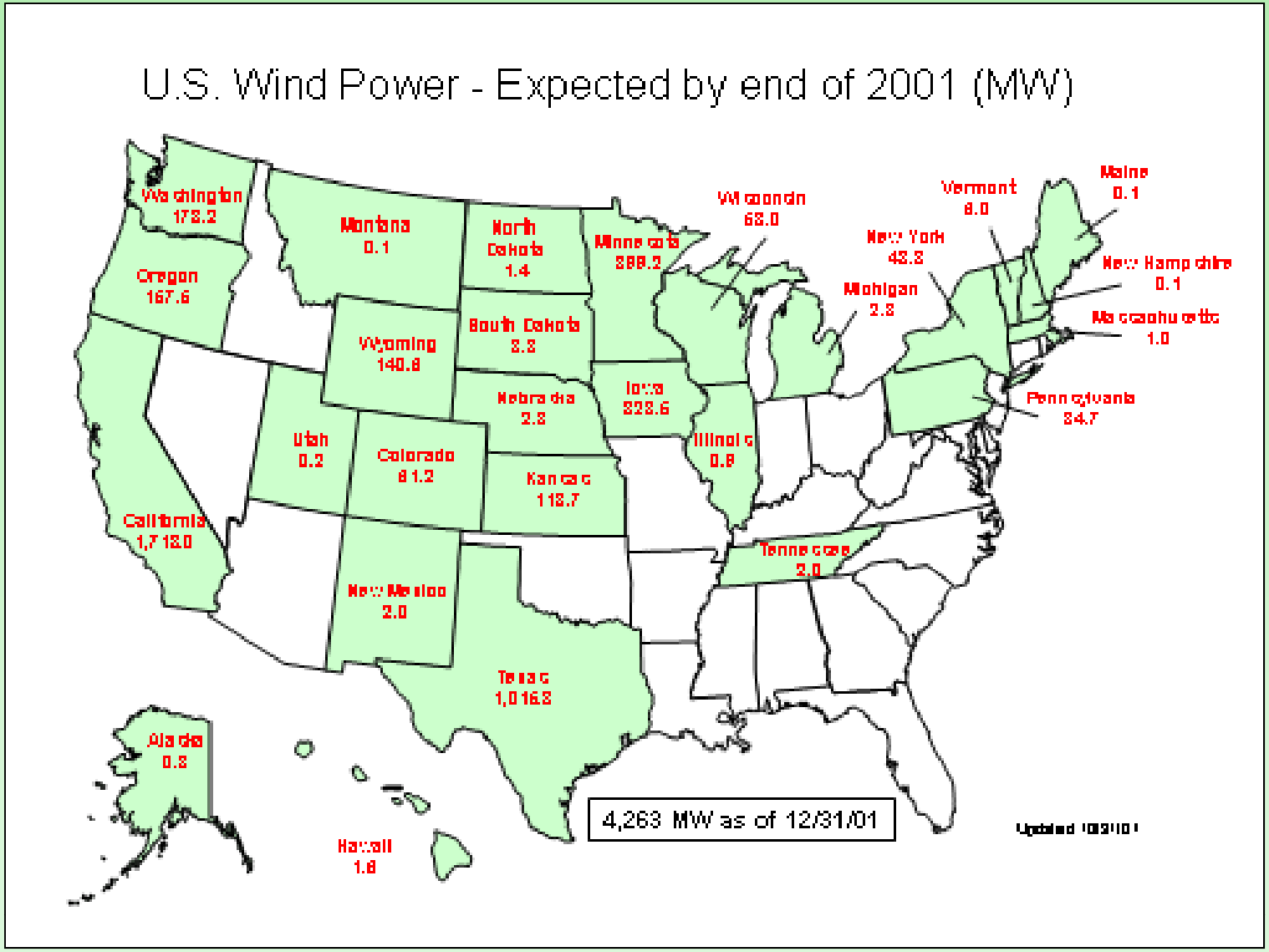
# America's First Off Shore Wind Farm: Cape Wind?


**N.I.M.B.Y**

The Debate

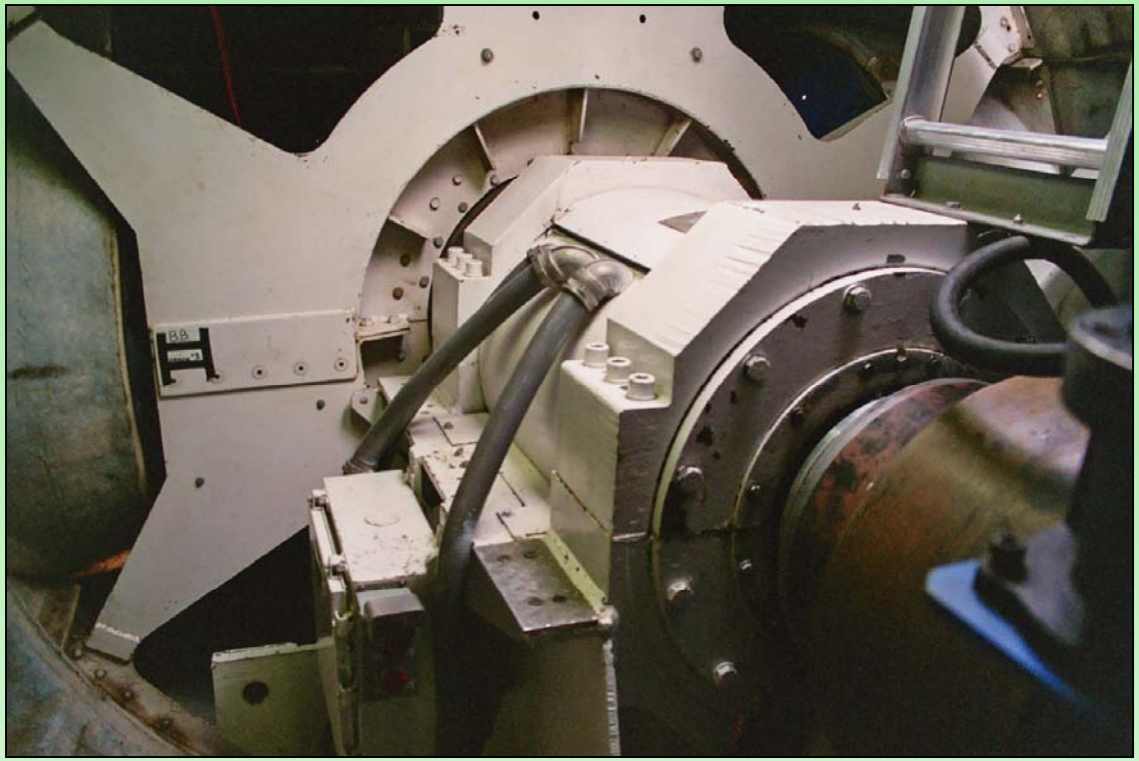
# Wind Energy - Future Growth




U.S. Wind Power - Expected by end of 2001 (MW)
Washington
173.2
Oregon
167.6
Montana
0.1
North Dakota
1.4
Minnesota
899.2
Wisconsin
68.0
Vermont
6.0
Maine
0.1
New York
42.2
New Hampshire
0.1
Michigan
2.2
Massachusetts
1.0
Wyoming
140.8
South Dakota
8.2
Nebraska
2.2
Iowa
223.6
Pennsylvania
24.7
Illinois
0.9
Utah
0.2
Colorado
81.2
Kansas
113.7
California
1,712.0
Tennessee
2.0
New Mexico
2.0
Texas
1,016.2
Alaska
0.2
Hawaii
1.8
4,263 MW as of 12/31/01
Updated 1/23/101

# Inside a wind turbine

National Wind Technology Site
Golden, Colorado



# The Turbine

One more ladder to go.

Looking into Coal Creek Canyon, where a nesting pair of Eagles live.


DOE/NREL

# Wind Coast-to-Coast

# Downtown Denver

# Wind Energy

## BENEFITS

- ✓ Does little or no harm to the environment.
- ✓ Can supply electricity and water pumping
- ✓ Small or large systems available.
- ✓ Can be located offshore.
- ✓ Can coexist with farming and other land uses.
- ✓ Energy supply is endless.

## CONCERNS

- ✓ Currently more expensive than fossil fuels.
- ✓ Most of the costs involved are for start-up infrastructure.
- ✓ Power generation is intermittent
- ✓ Spoil the view?

✓Energy Sources

✓✓Renewable Energy

✓Bioenergy

# Bioenergy

**Biomass Energy-** the use of plants and grains to produce useable fuels for cars, heating, or electricity production.

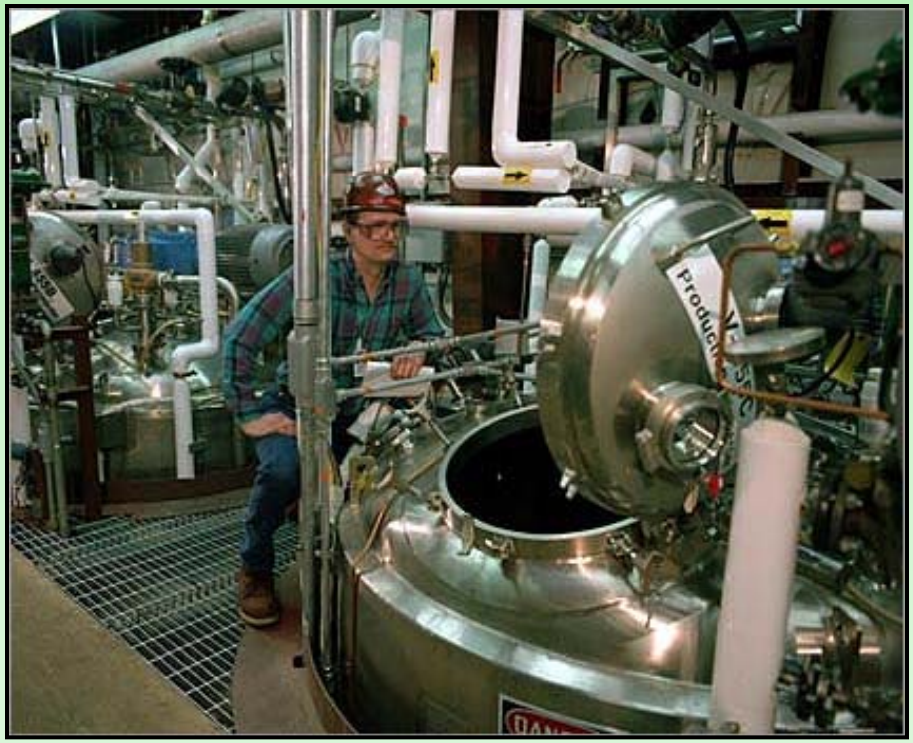
# Types of Biomass Available

Corn Stover

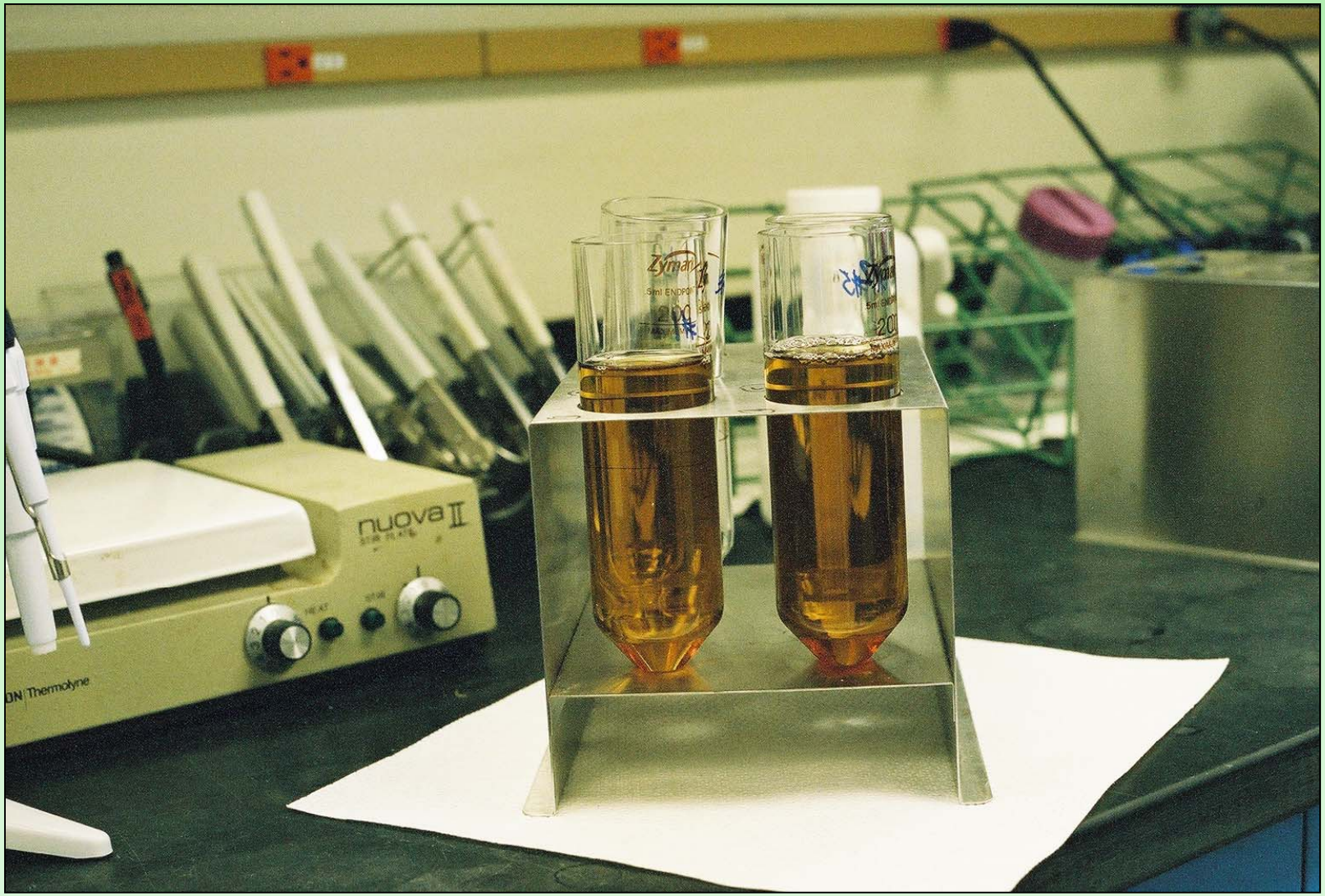

Corn Stover

# Turning Corn Stover into Fuel

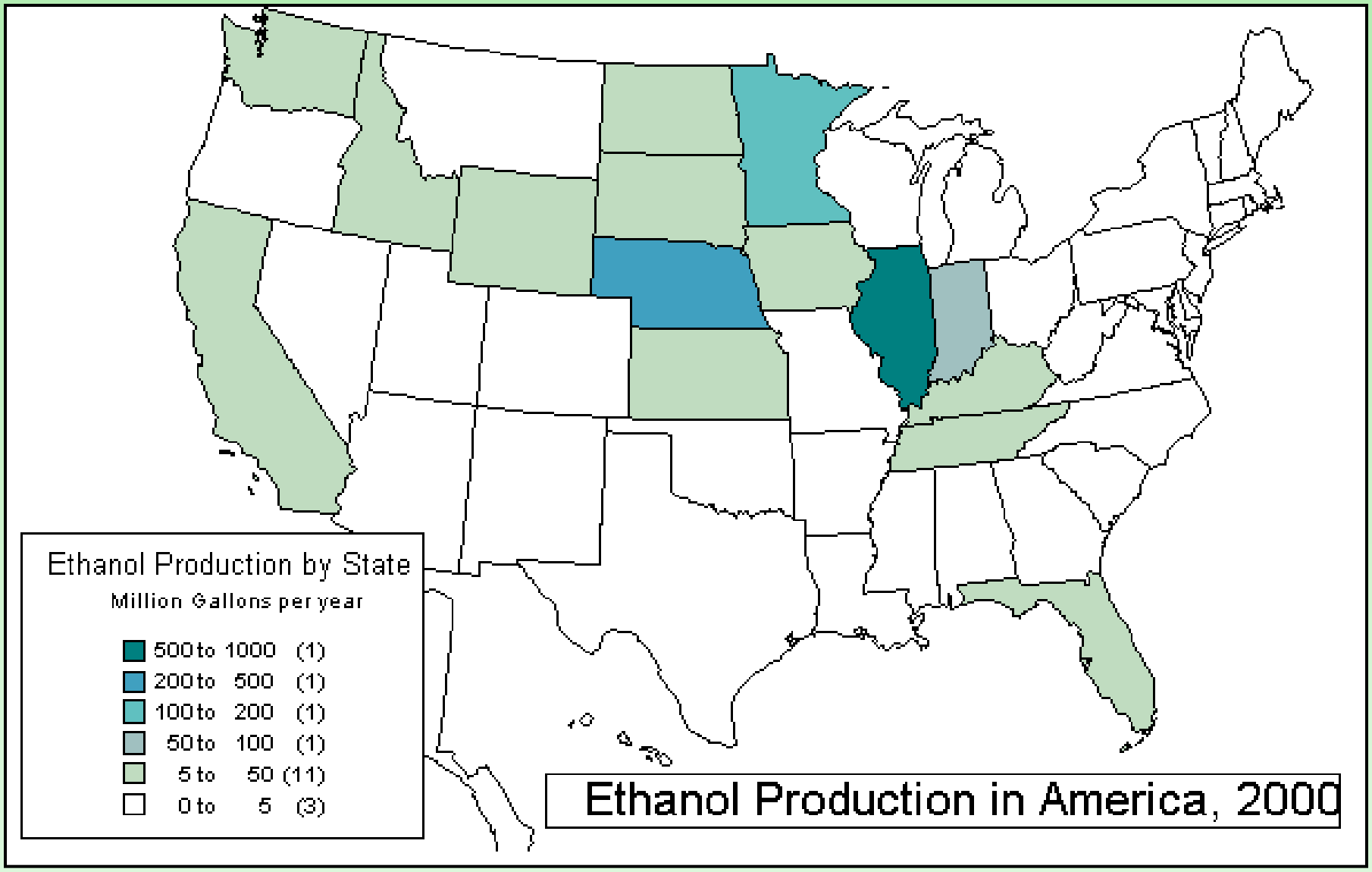
Syngas



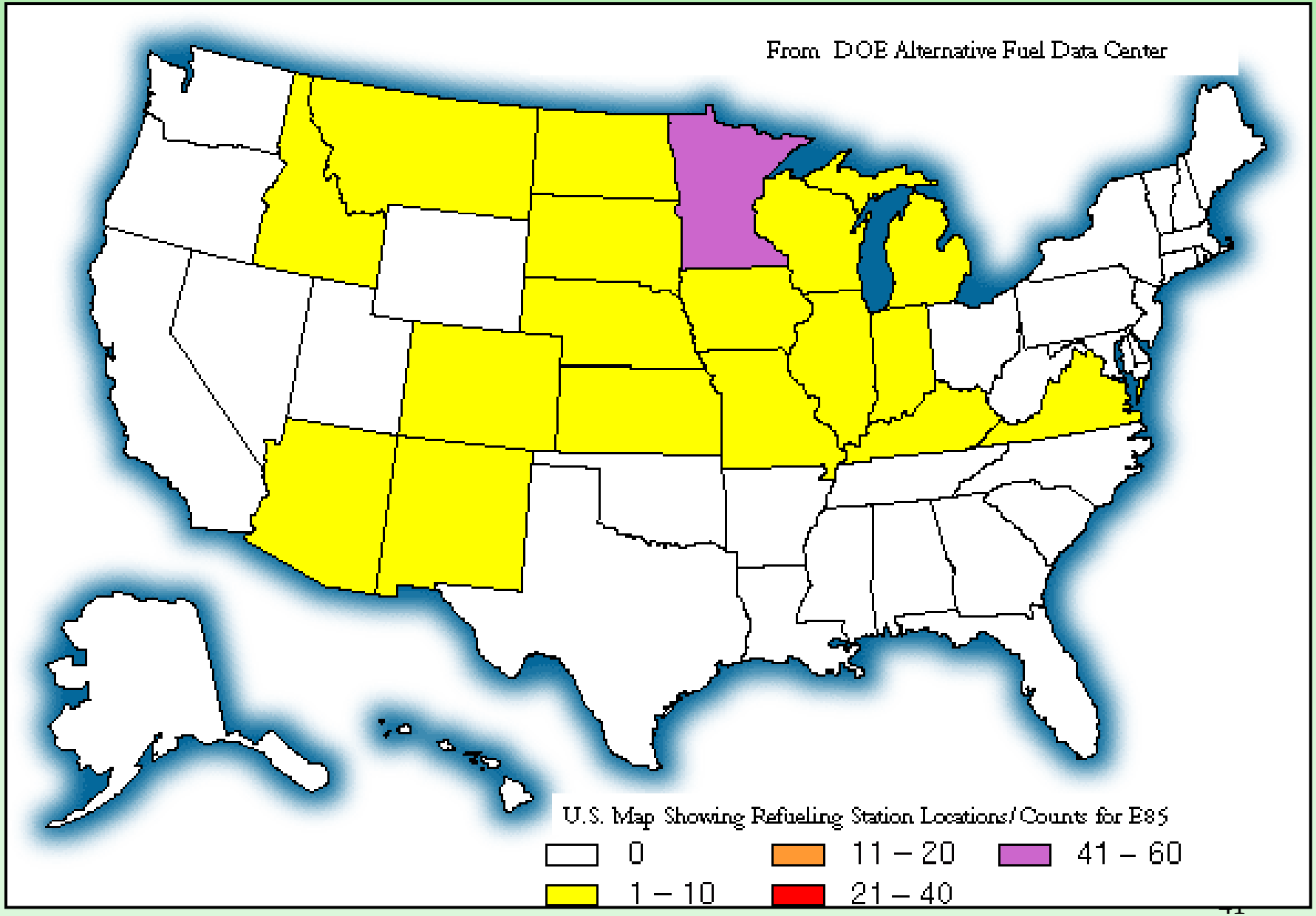
Ethanol




Sugar extracted from corn stover




http://www.bio-energy-inc.com/existing3.gif


From DOE Alternative Fuel Data Center
U.S. Map Showing Refueling Station Locations/Counts for E85
0
1 – 10
11 – 20
21 – 40
41 – 60

# Additional Biomass Sources

Switch Grass

Napier Grass

# Additional Biomass Sources

Sugar Cane

# Additional Biomass Sources

Harvesting Popular Trees

Charcoal from Sawdust

**Biomass Research Farm**

# Bioenergy

## BENEFITS

- ✓ Little to no harm to the environment.
- ✓ Can supply electricity, fuels and heat.
- ✓ Energy supply is readily available and sustainable.

## CONCERNS

- ✓ Currently more expensive than fossil fuels.
- ✓ Infrastructure to support bioenergy needs expanding.

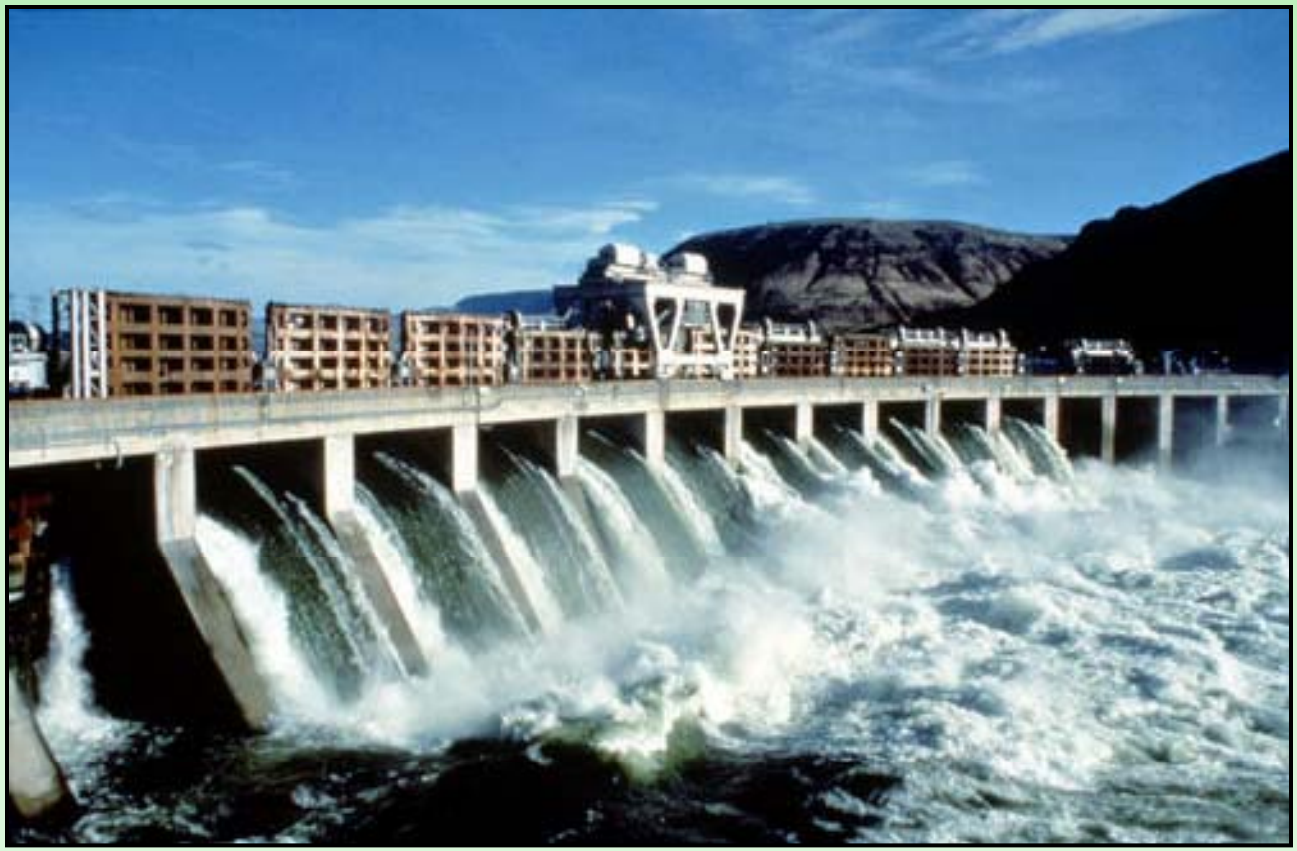
✓ Energy Sources

✓ ✓ Renewable Energy

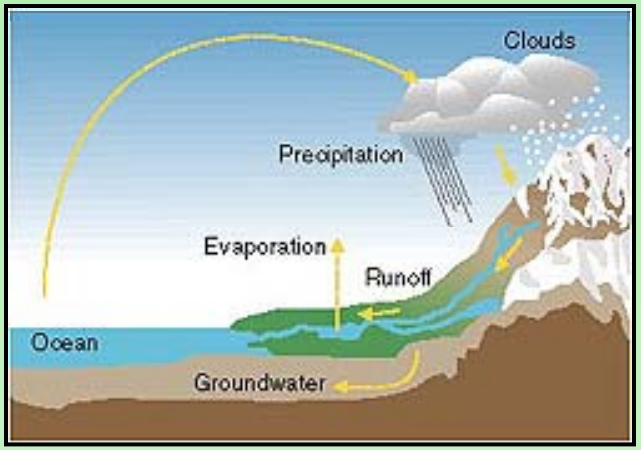
✓ Hydroelectric

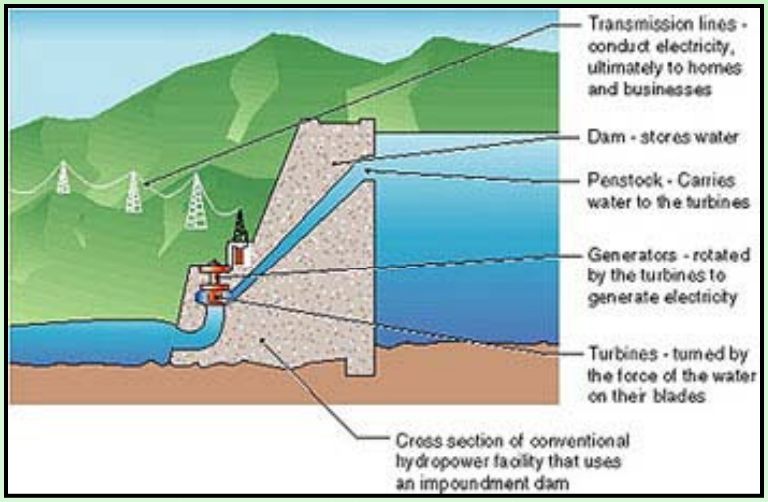
# Hydroelectric Energy

✓ Water pulled by gravity can turn a turbine and make electricity



# Tapping into Earth's water cycle




✓http://www.hdprint.co.uk/ftp/CanyonLands/212%20-%20Glen%20Canyon%20Dam%20from%20plane.jpg

# Hydoelectric Energy

## BENEFITS

- ✓ Can supply electricity at low cost per KWH
- ✓ No pollution
- ✓ Already in place in many countries
- ✓ Very high efficiency (80%)
- ✓ Recreation dollars
- ✓ Energy supply is sustainable.

## CONCERNS

- ✓ Dams and reservoirs can negatively impact humans and environment

✓Energy Sources

✓✓Renewable Energy

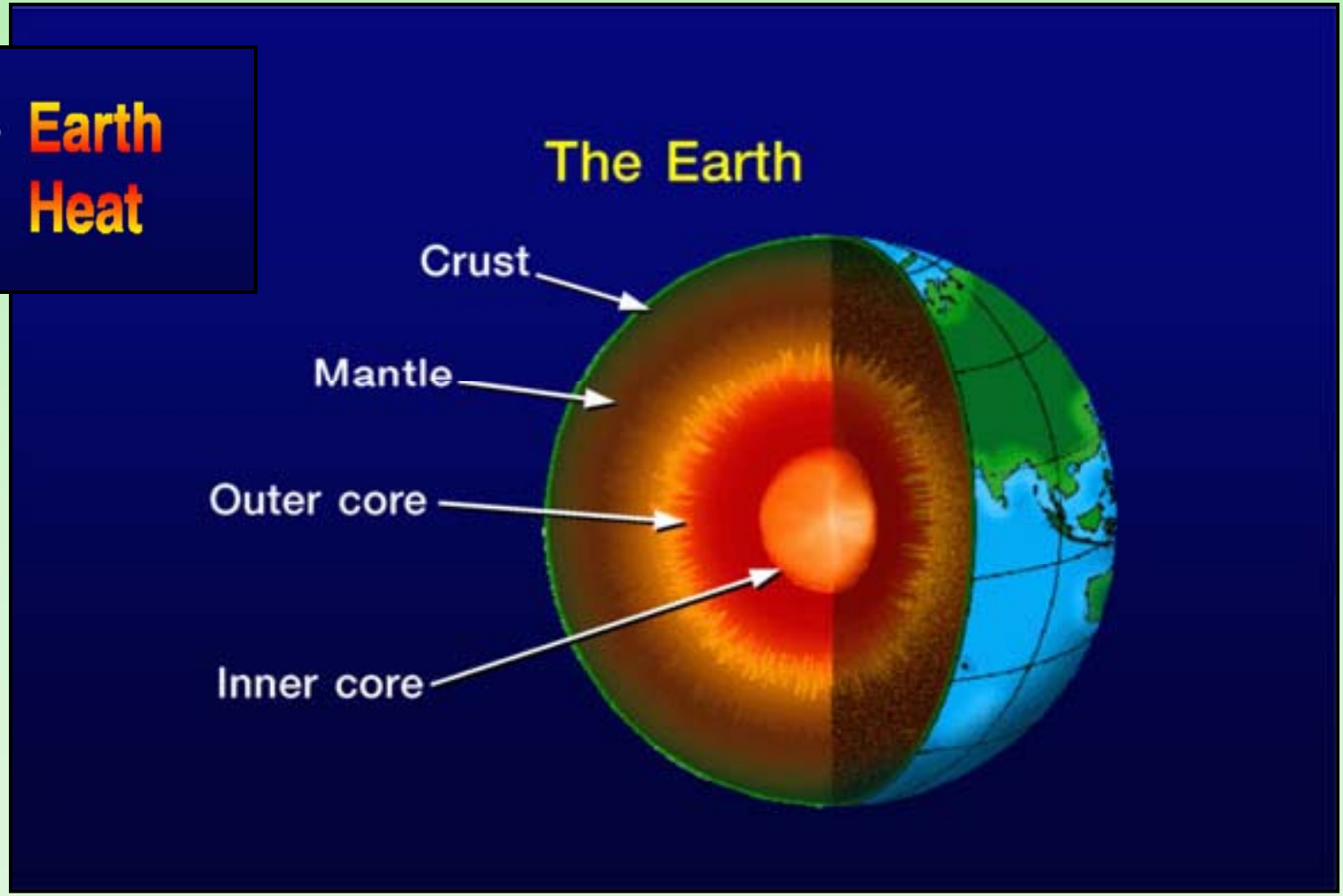
✓Geothermal

# Geothermal Energy

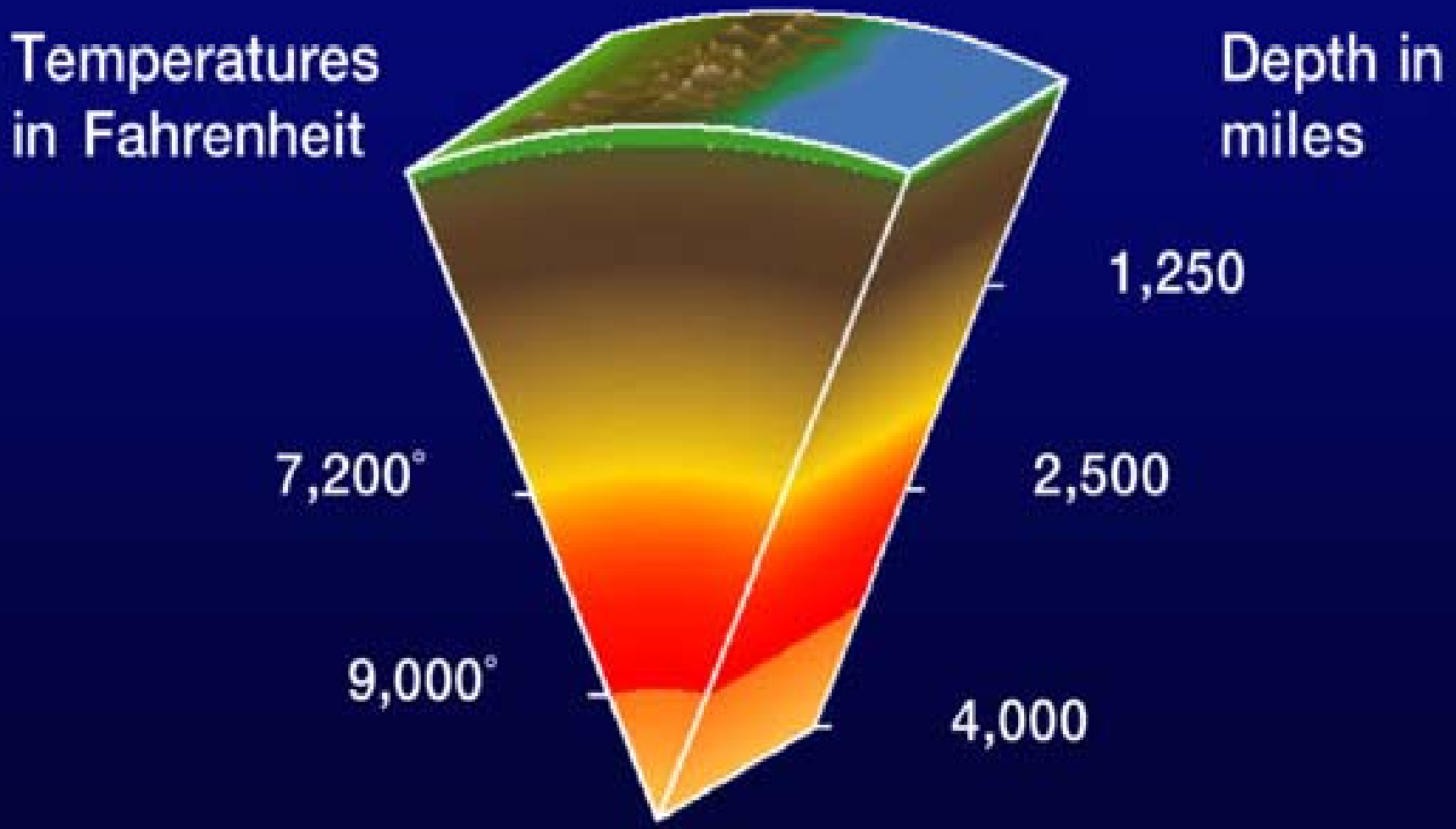
Geothermal- the harnessing of the internal heat of the earth's core to produce heat for homes or electricity.

Geo means **Earth**

Thermal means **Heat**



# Temperatures in the Earth



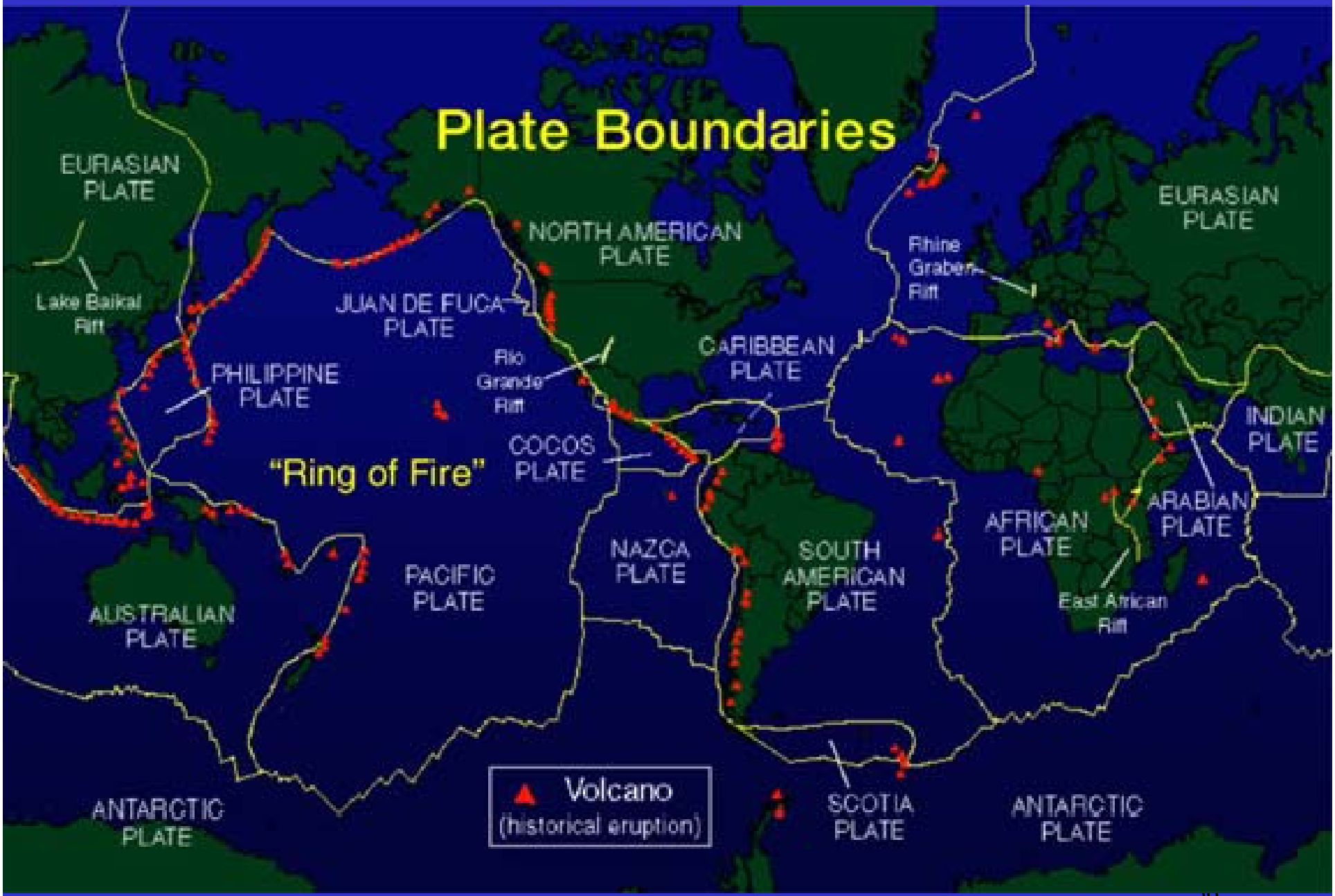
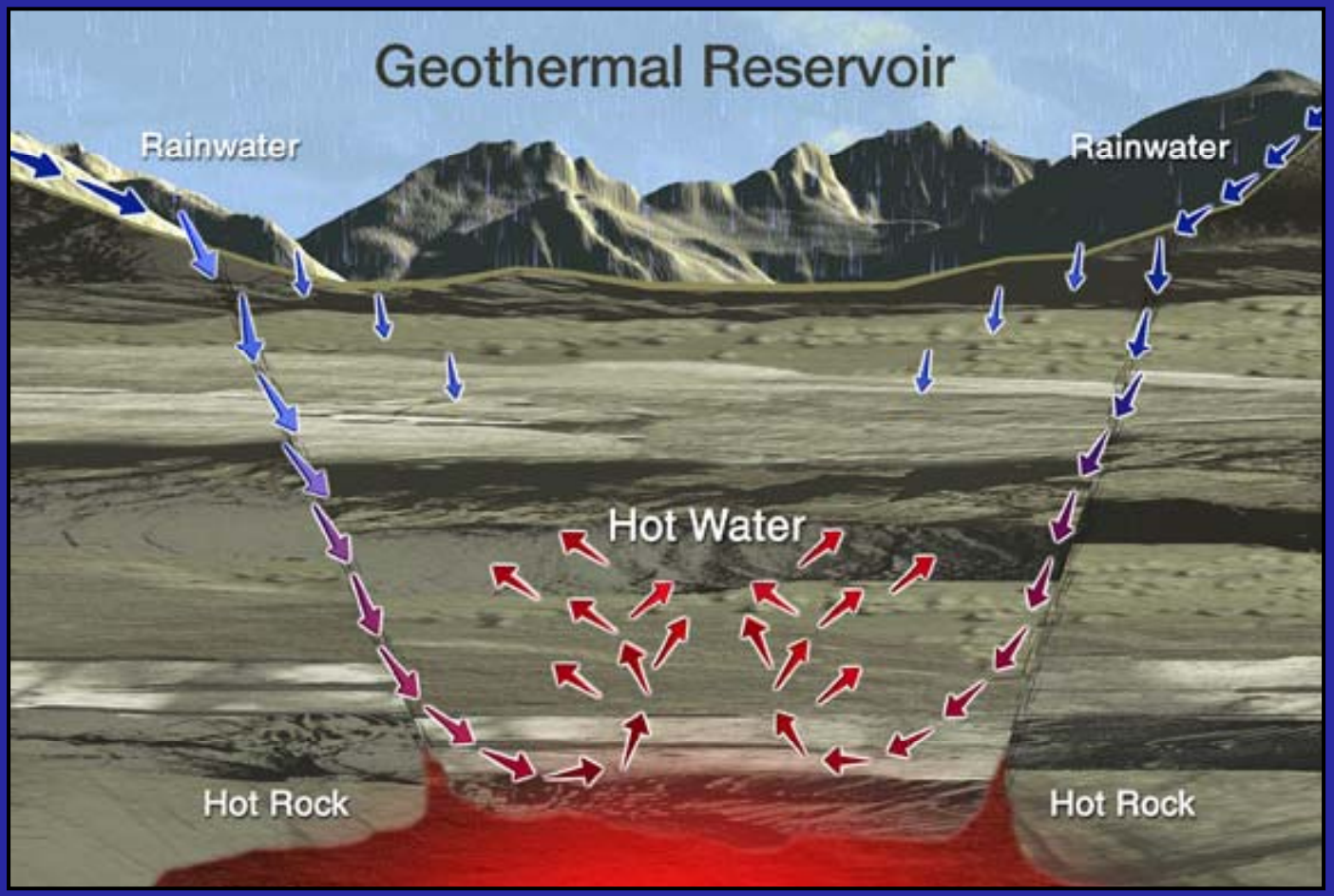
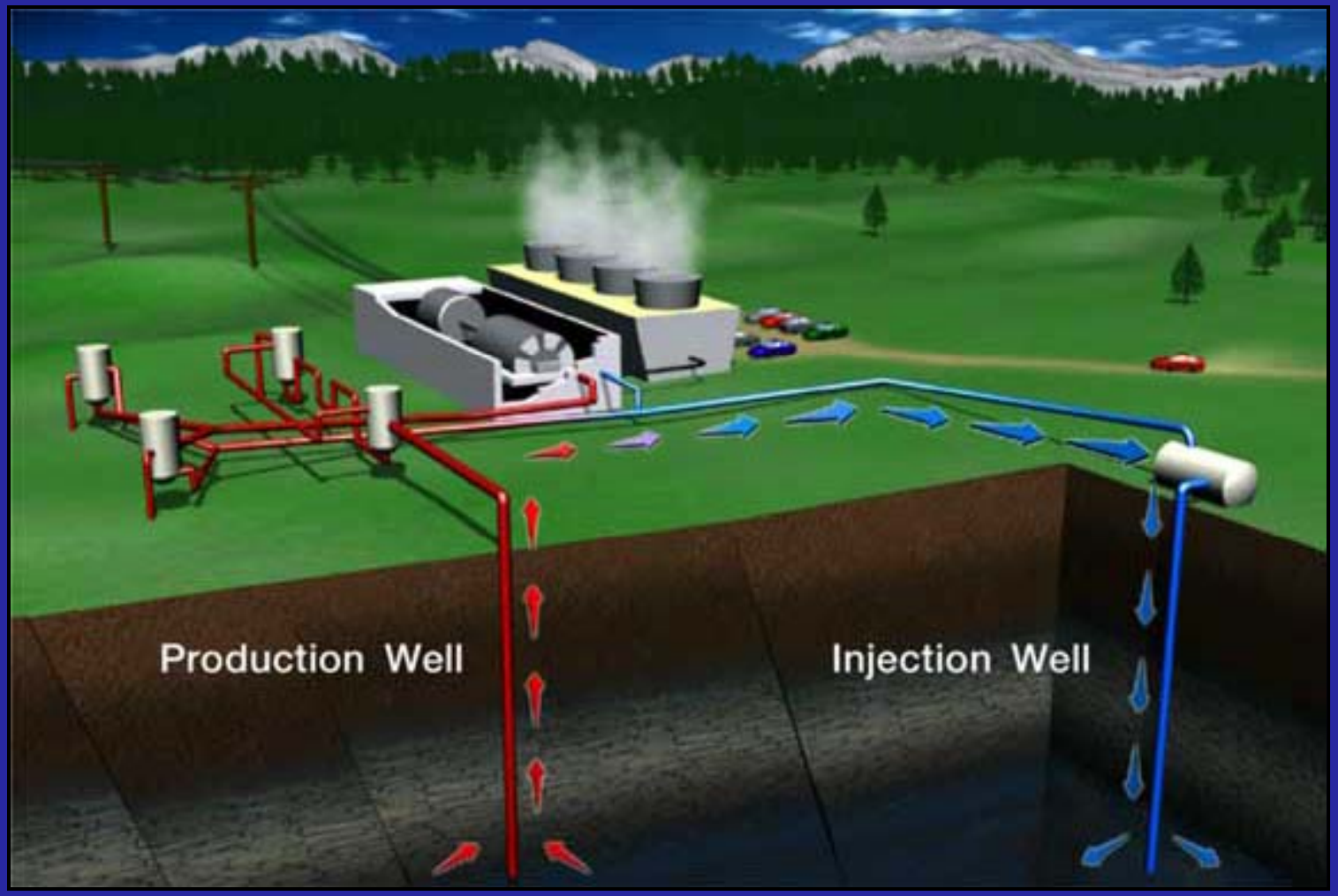
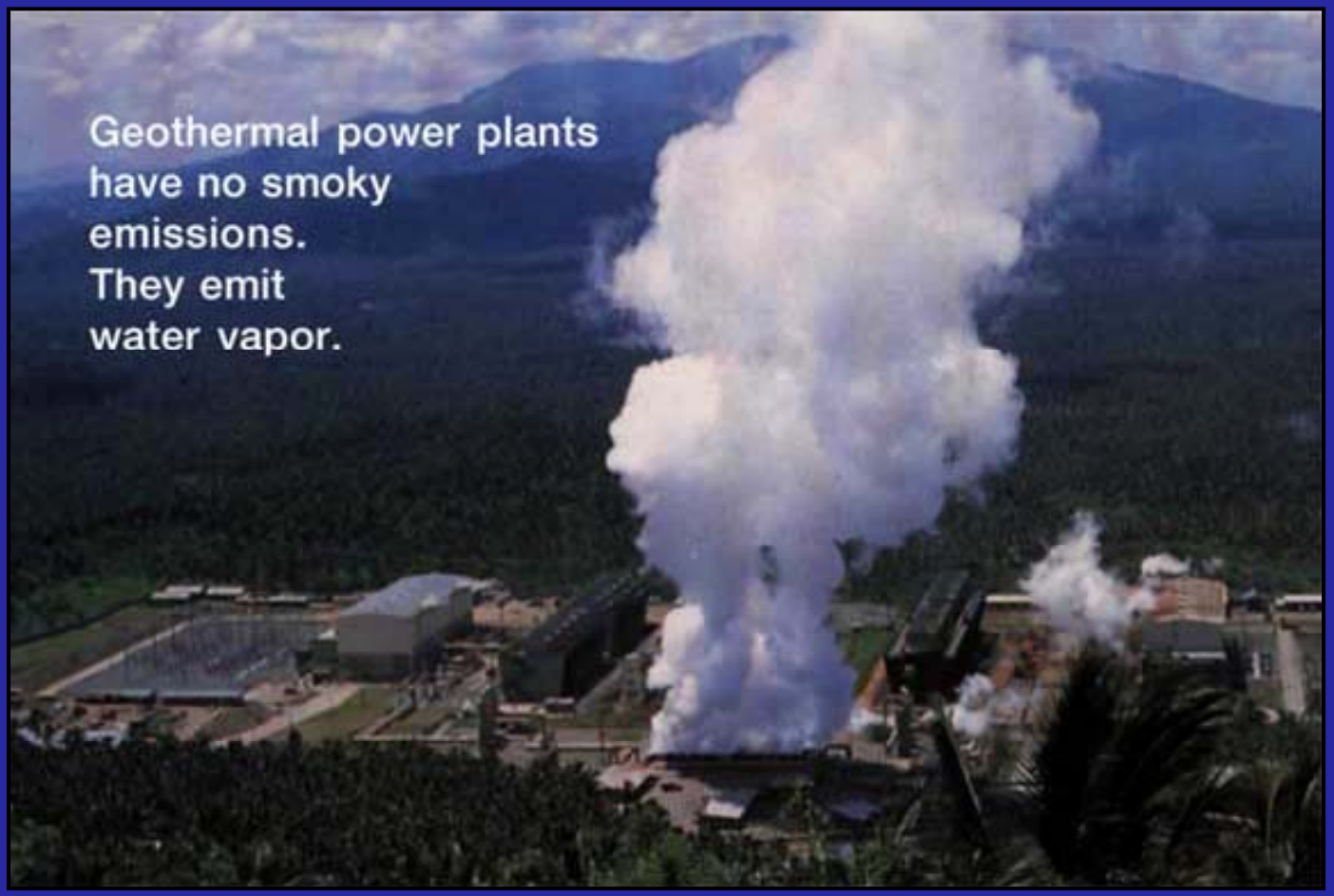


Plate Boundaries
EURASIAN PLATE
NORTH AMERICAN PLATE
EURASIAN PLATE
Lake Baikal Rift
Rhine Graben Rift
JUAN DE FUCA PLATE
CARIBBEAN PLATE
PHILIPPINE PLATE
Rio Grande Rift
INDIAN PLATE
COCOS PLATE
"Ring of Fire"
ARABIAN PLATE
AFRICAN PLATE
NAZCA PLATE
SOUTH AMERICAN PLATE
PACIFIC PLATE
East African Rift
AUSTRALIAN PLATE
Volcano
(historical eruption)
ANTARCTIC PLATE
SCOTIA PLATE
ANTARCTIC PLATE


Geothermal Reservoir
Rainwater
Rainwater
Hot Water
Hot Rock
Hot Rock

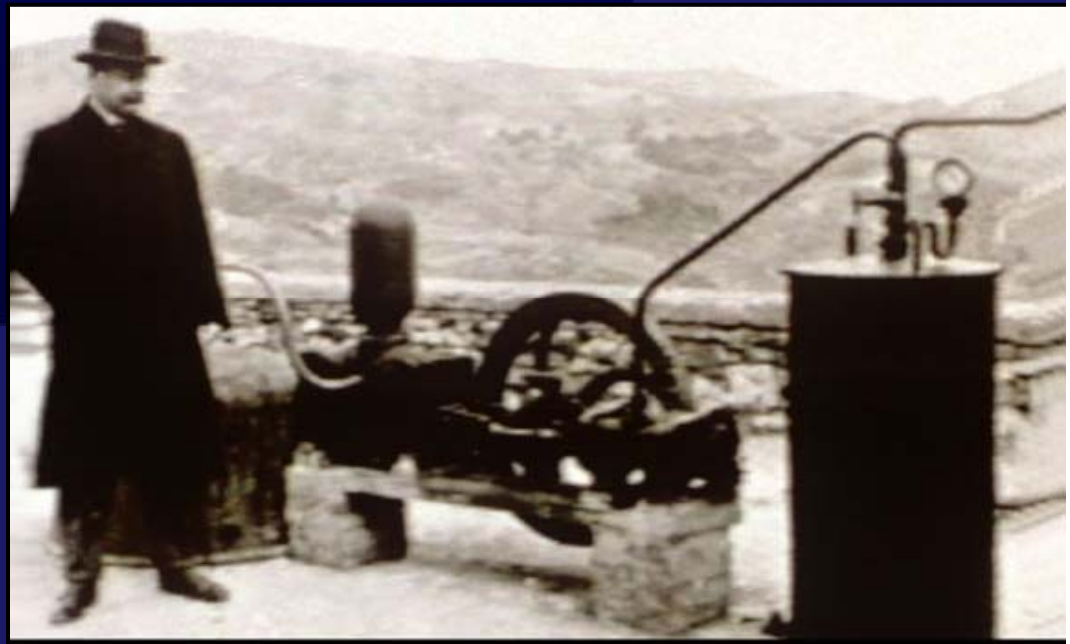

Production Well
Injection Well


Geothermal power plants
have no smoky
emissions.
They emit
water vapor.

## Easy on the Environment

Geothermal power plants have been built:

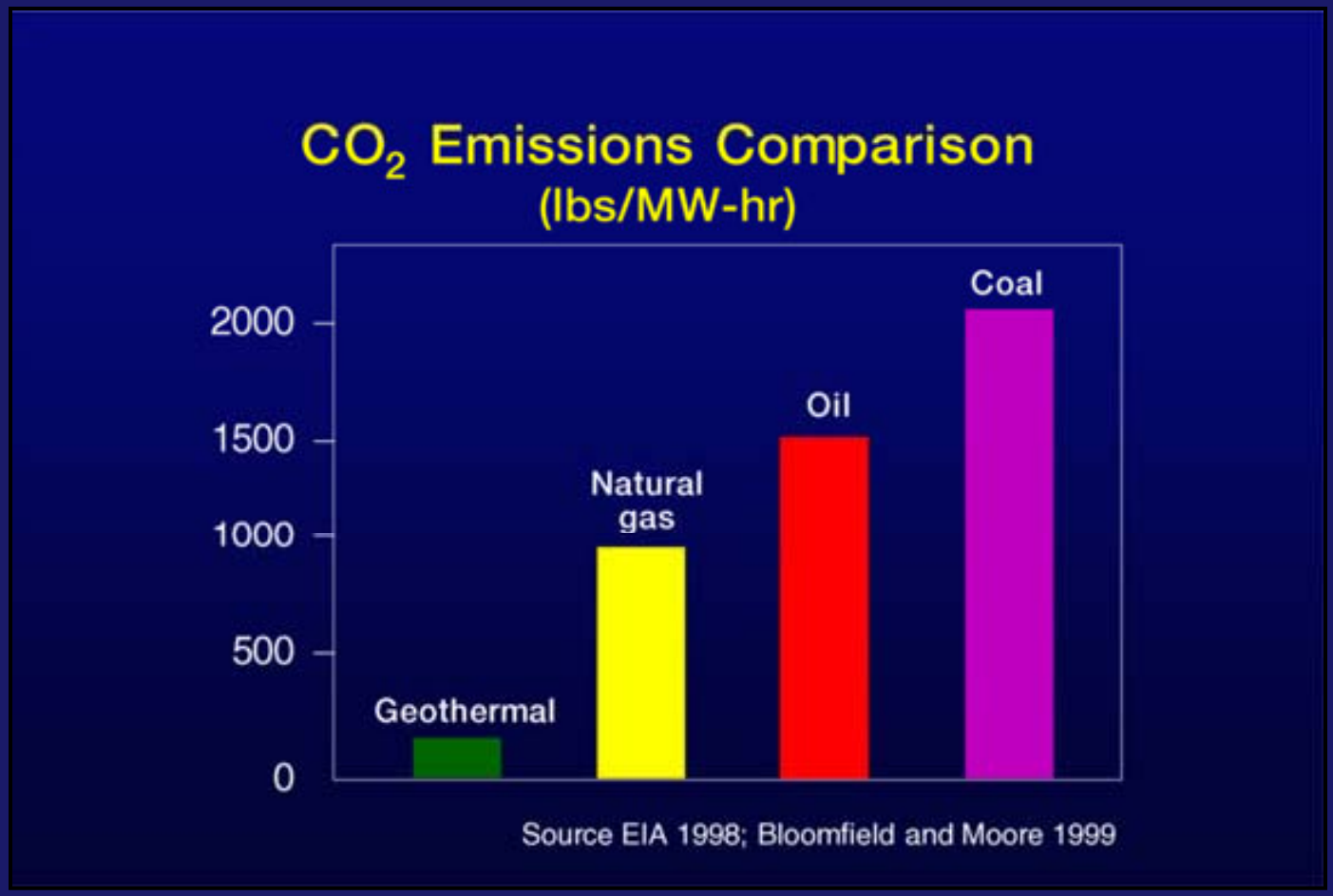
- In the middle of crops
- In forested recreation areas
- In fragile deserts
- In tropical forests

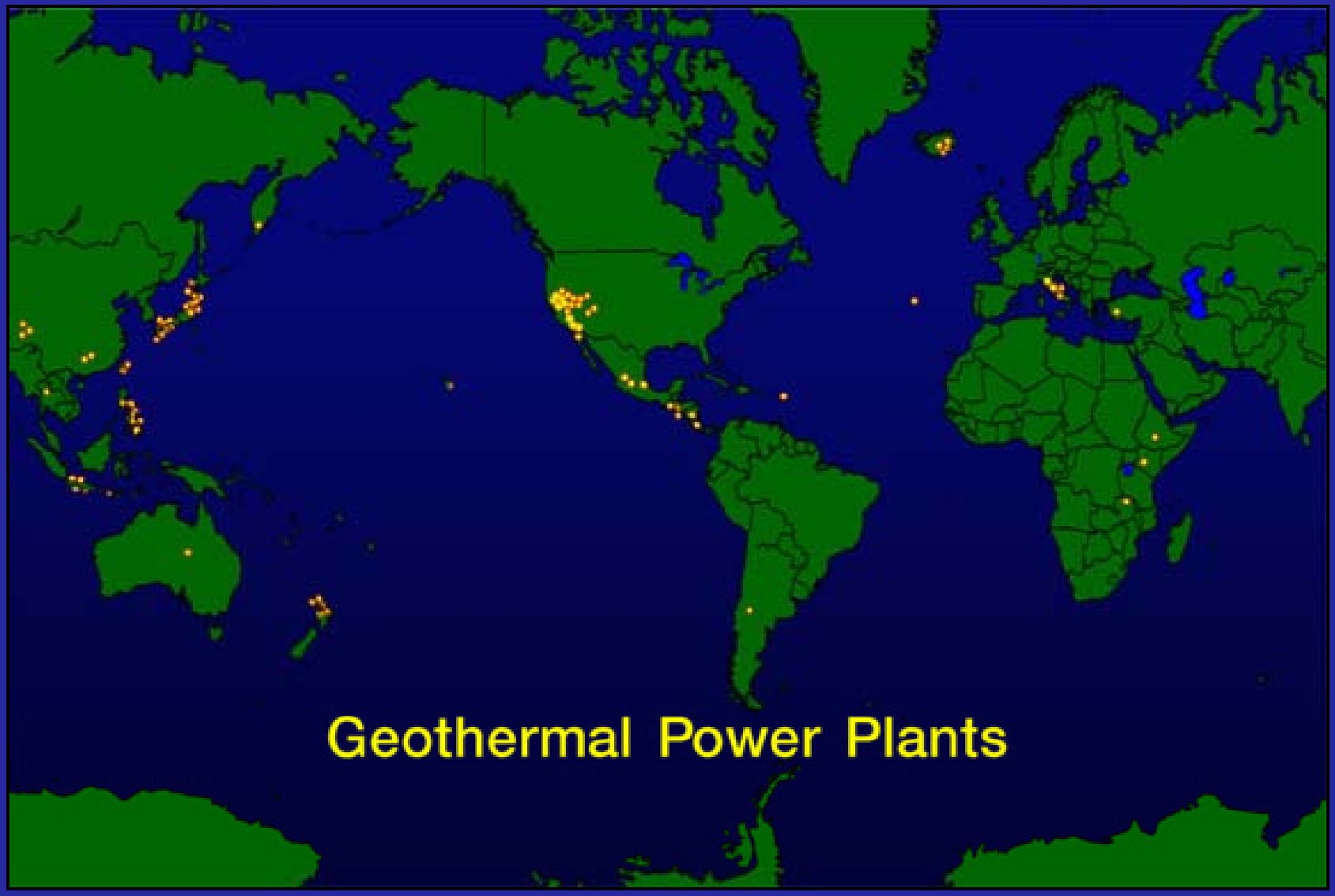


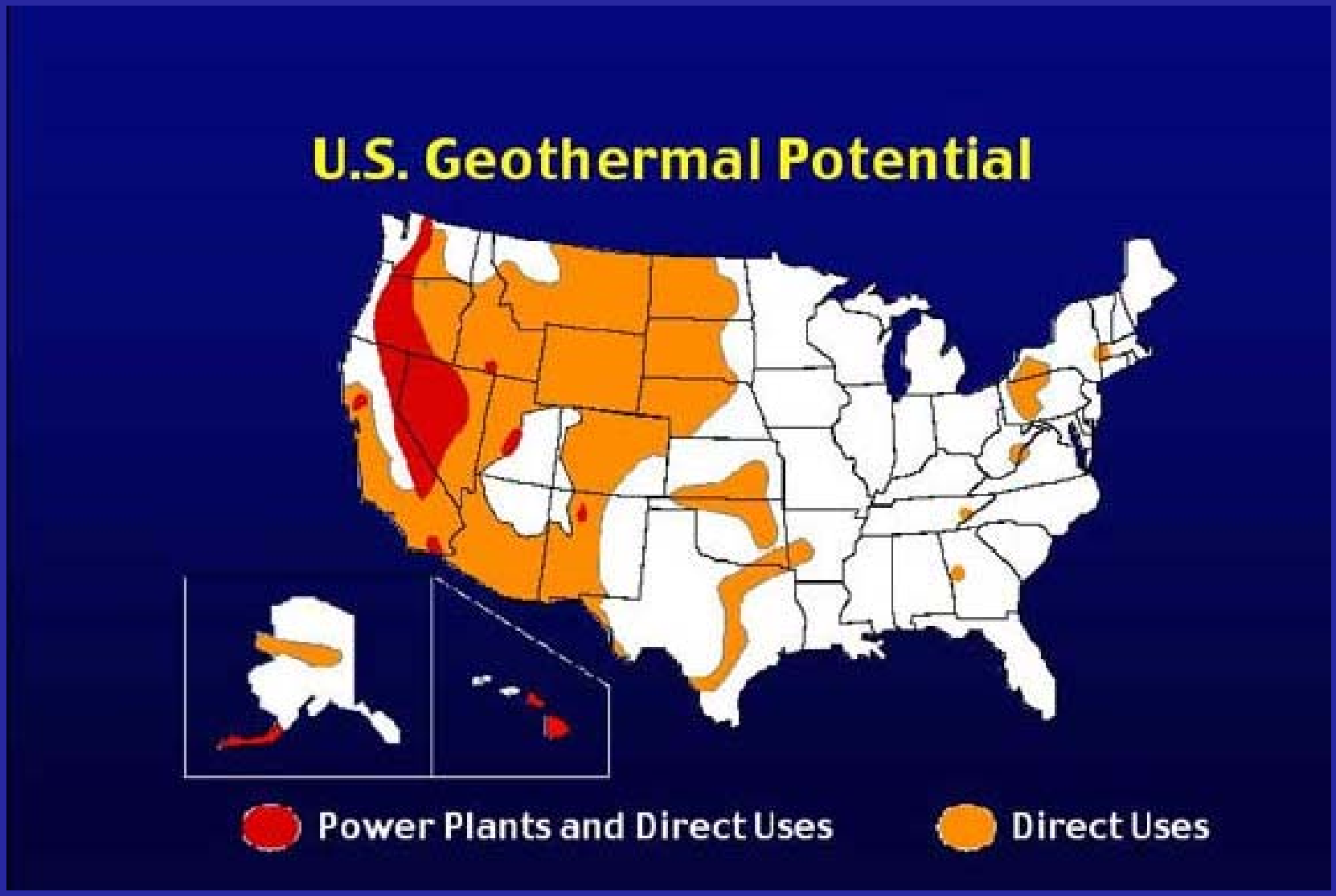
First Geothermal Power Plant, 1904, Larderello, Italy

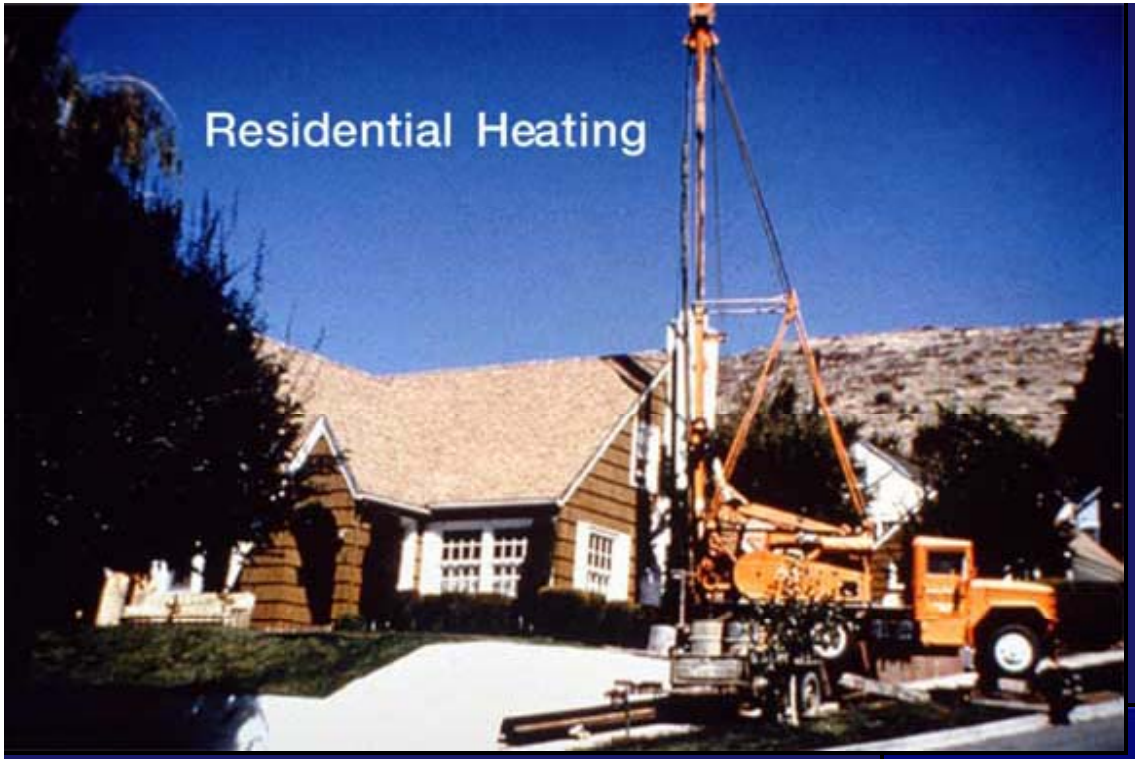
## Benefits of Geothermal Power

- Provides clean and safe energy using little land
- Is renewable and sustainable
- Generates continuous, reliable "baseload" power
- Conserves fossil fuels and contributes to diversity in energy sources
- Avoids importing and benefits local economies
- Offers modular, incremental development and village power to remote sites

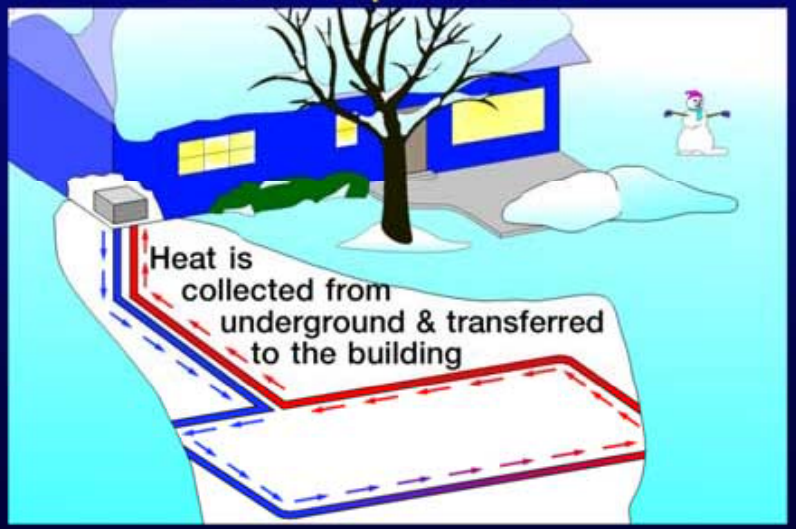

$CO_2$ Emissions Comparison
(lbs/MW-hr)
2000
1500
1000
500
0
Geothermal
Natural gas
Oil
Coal
Source EIA 1998; Bloomfield and Moore 1999


Geothermal Power Plants

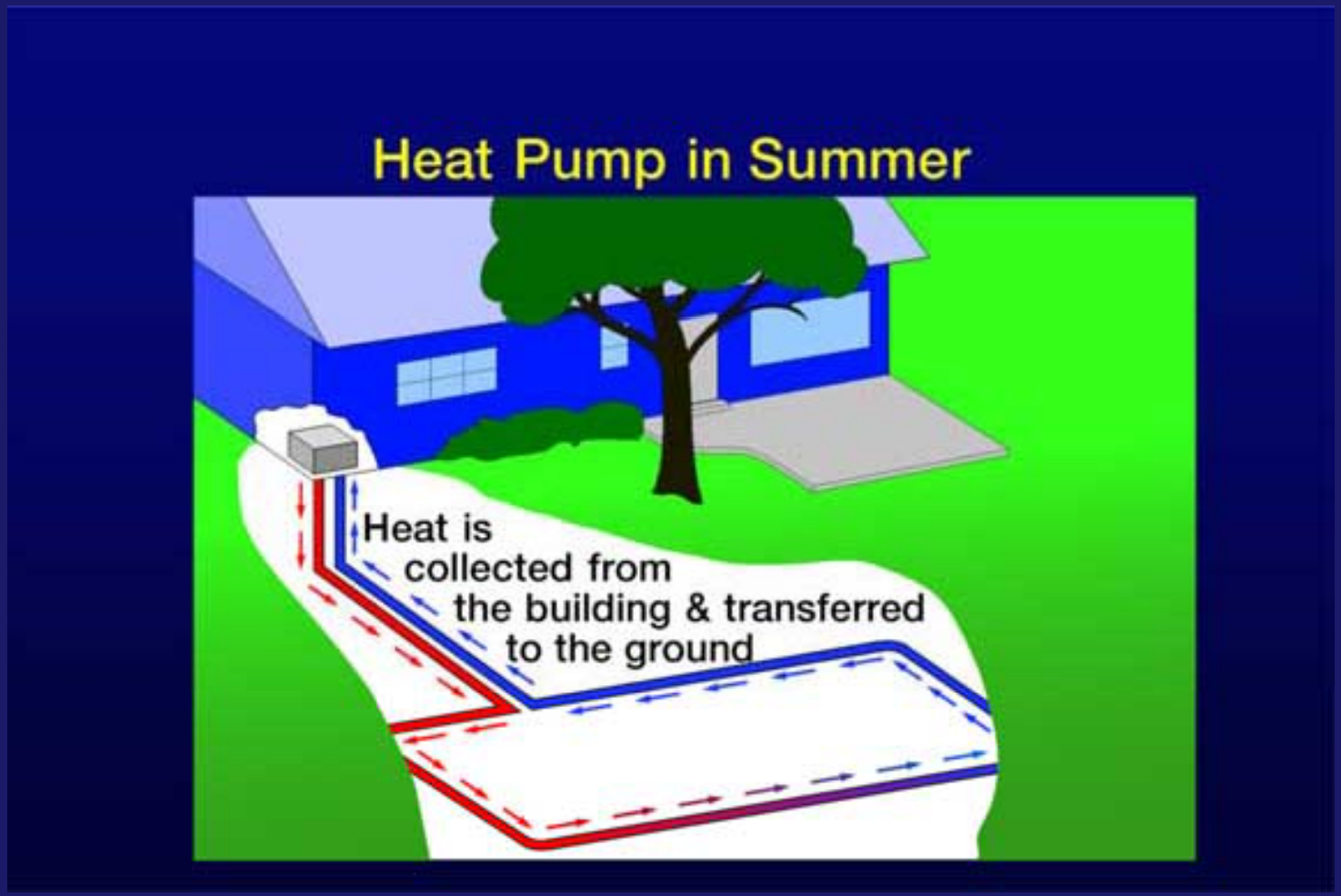

U.S. Geothermal Potential
Power Plants and Direct Uses
Direct Uses



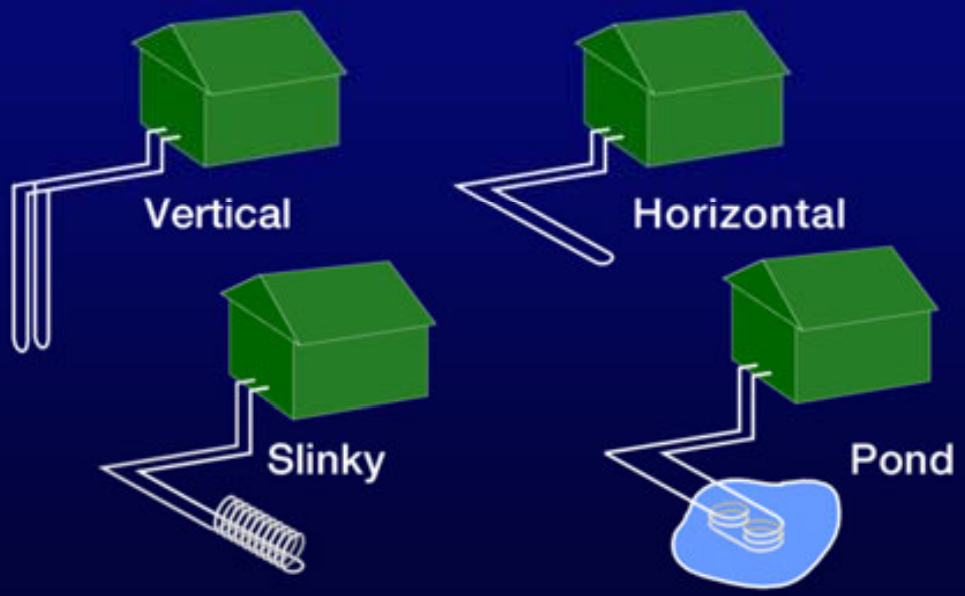

## Heat Pump in Winter



# Cooling


Heat Pump in Summer
Heat is
collected from
the building & transferred
to the ground

# Heat Pump Ground Loops




## Cleaning Up Our Air

Each year 22 million tons of carbon dioxide,
200 thousand tons of nitrogen oxides
and 110 thousand tons of particulate matter
are not emitted to the atmosphere because
we used electricity from geothermal resources
rather than burning fossil fuels.

## Benefits of Geothermal Heat Pumps

- Can be used almost everywhere worldwide
- Are energy- and cost-efficient
- Conserve fossil fuel resources
- Provide clean heating and cooling -- no emissions from burning fuels

Where do we go from here?


What else should be done?

# Renewable Energy Review

**Types**

- ✓ Solar
- ✓ Wind
- ✓ Bioenergy
- ✓ Hydroelectric
- ✓ Hydrogen/Fuel Cells
- ✓ Geothermal

# Renewable Energy Review

**BENEFITS**

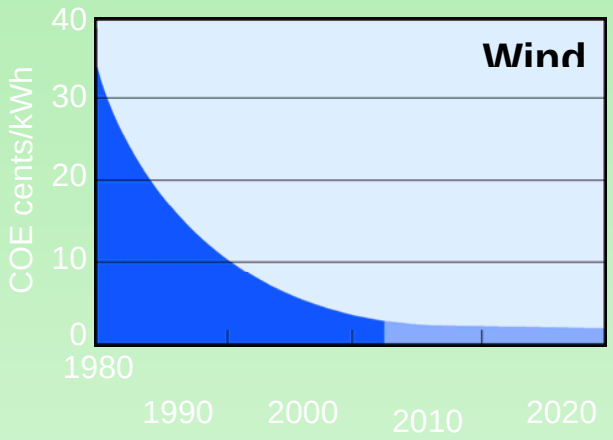
- ✓ Environmentally clean energy.
- ✓ Using a variety of sources, all of our energy needs can be fulfilled.
- ✓ Provides jobs and economic benefits.
- ✓ Diversity of supplies helps national security.
- ✓ Reduces geopolitical pressures. (No more war for oil)
- ✓ Energy supply is endless.

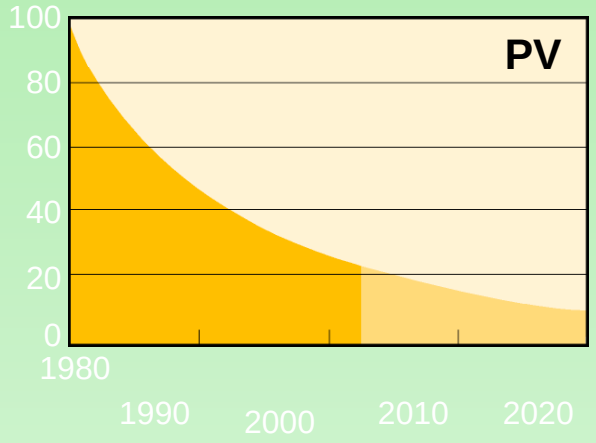
## Addressing the CONCERNS

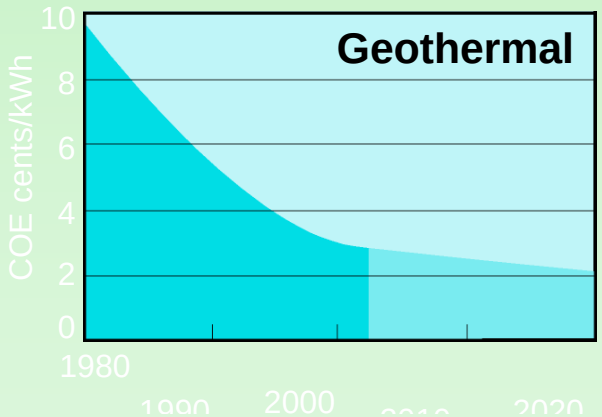
- ✓ Costs are already going down for renewables and will improve even more with mass production.
- ✓ Americans are paying more than ever for gasoline. When will the general public demand the switch to renewables? $4.00/gal? $5.00?
- ✓ Start-up infrastructure cost will pay off in short time.
- ✓ Progressive approach to diminishing supplies of fossil fuels.

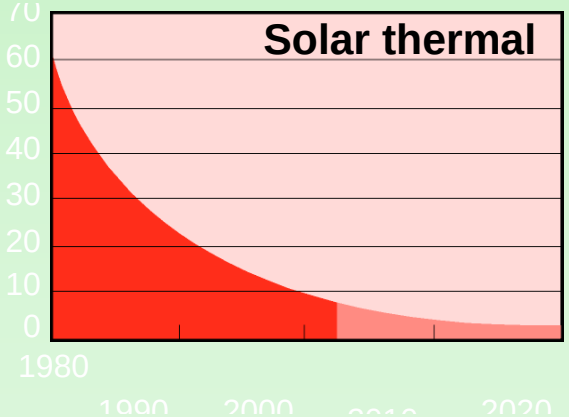
# Renewable Energy Cost Trends

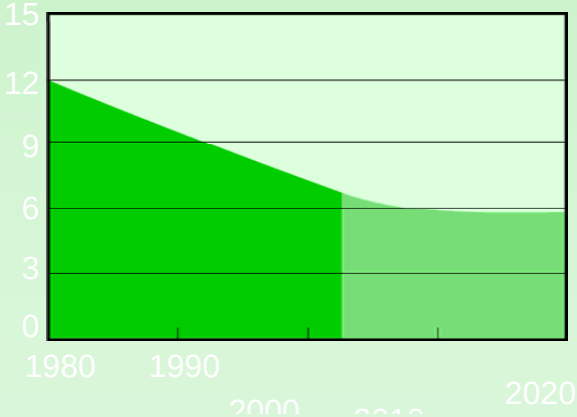
**Levelized cents/kWh in constant $2000[1]**




Source: NREL Energy Analysis Office

[1]These graphs are reflections of historical cost trends NOT precise annual historical data.

Updated: October 2002

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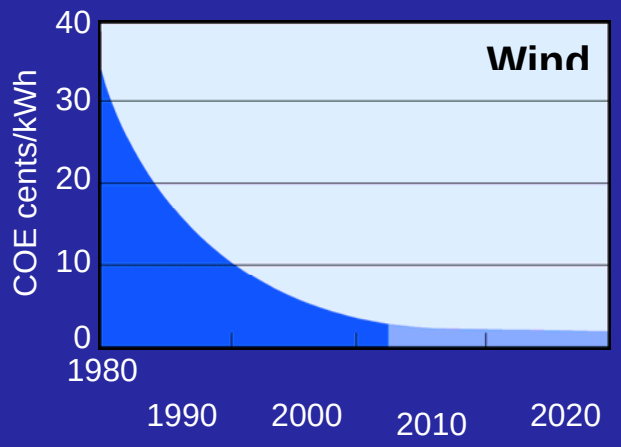


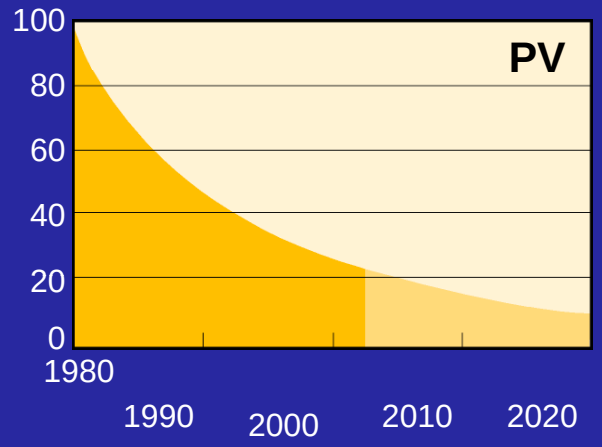


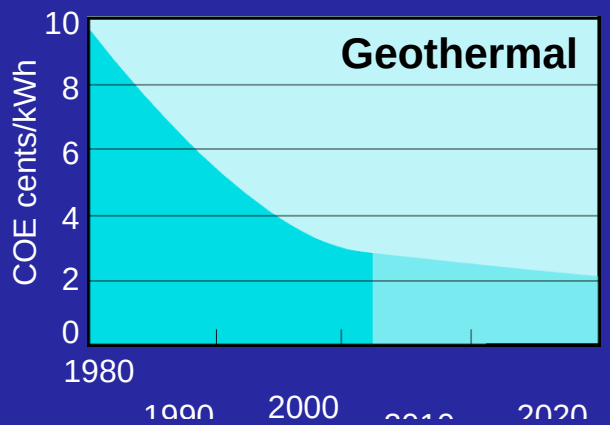


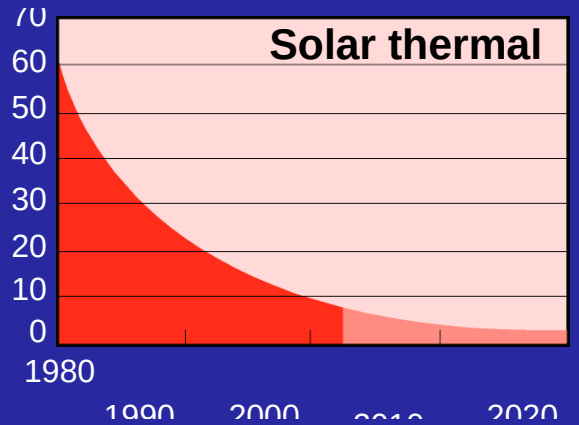


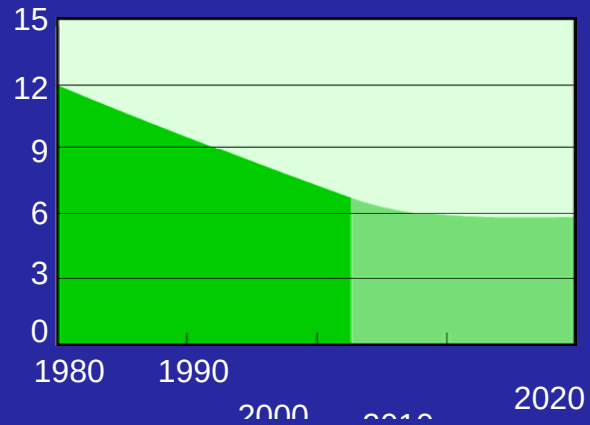


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