

Renewable Energy

Diana Maneta

Montana Renewable Energy Association



UM-Bitterroot

November 10, 2010

Photo credit: Sustainable Building Systems, Missoula

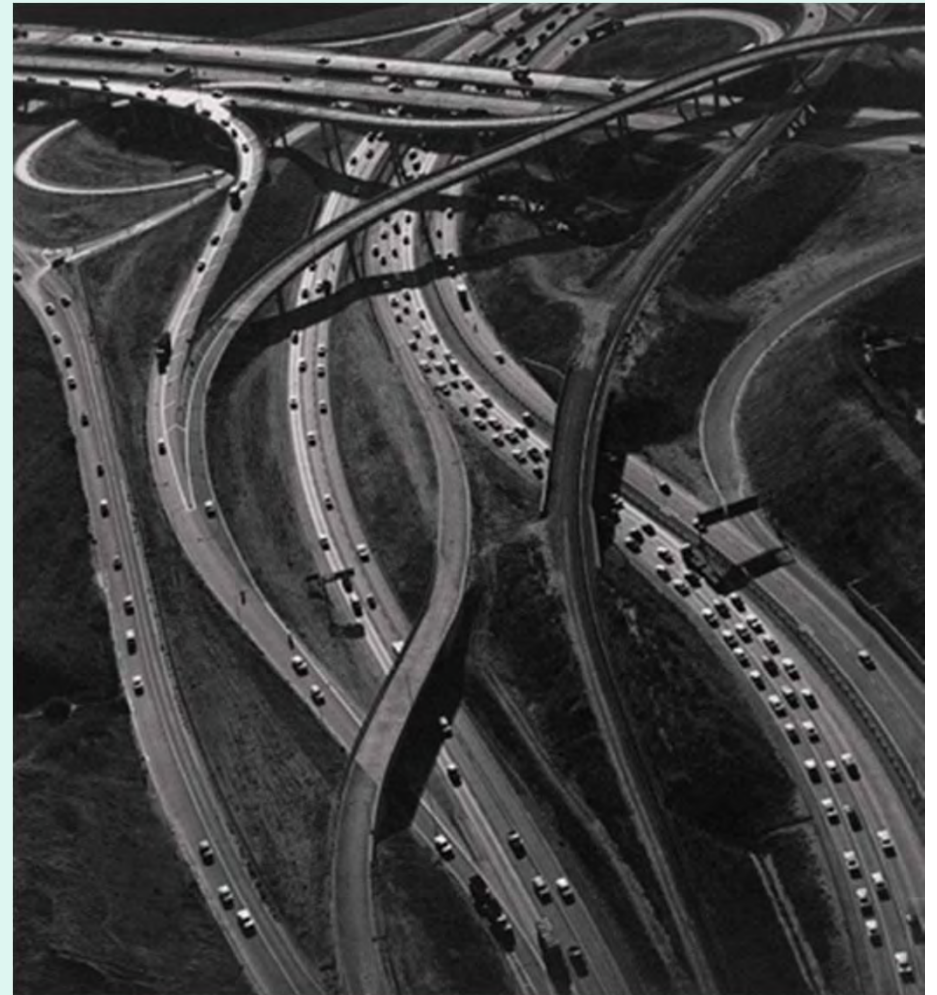
The Problem of Climate Change Is a Problem of **Energy**

Fossil fuel combustion accounts for more than **75%**
of the increase in atmospheric CO₂
since preindustrial times.

(IPCC Fourth Assessment Report)

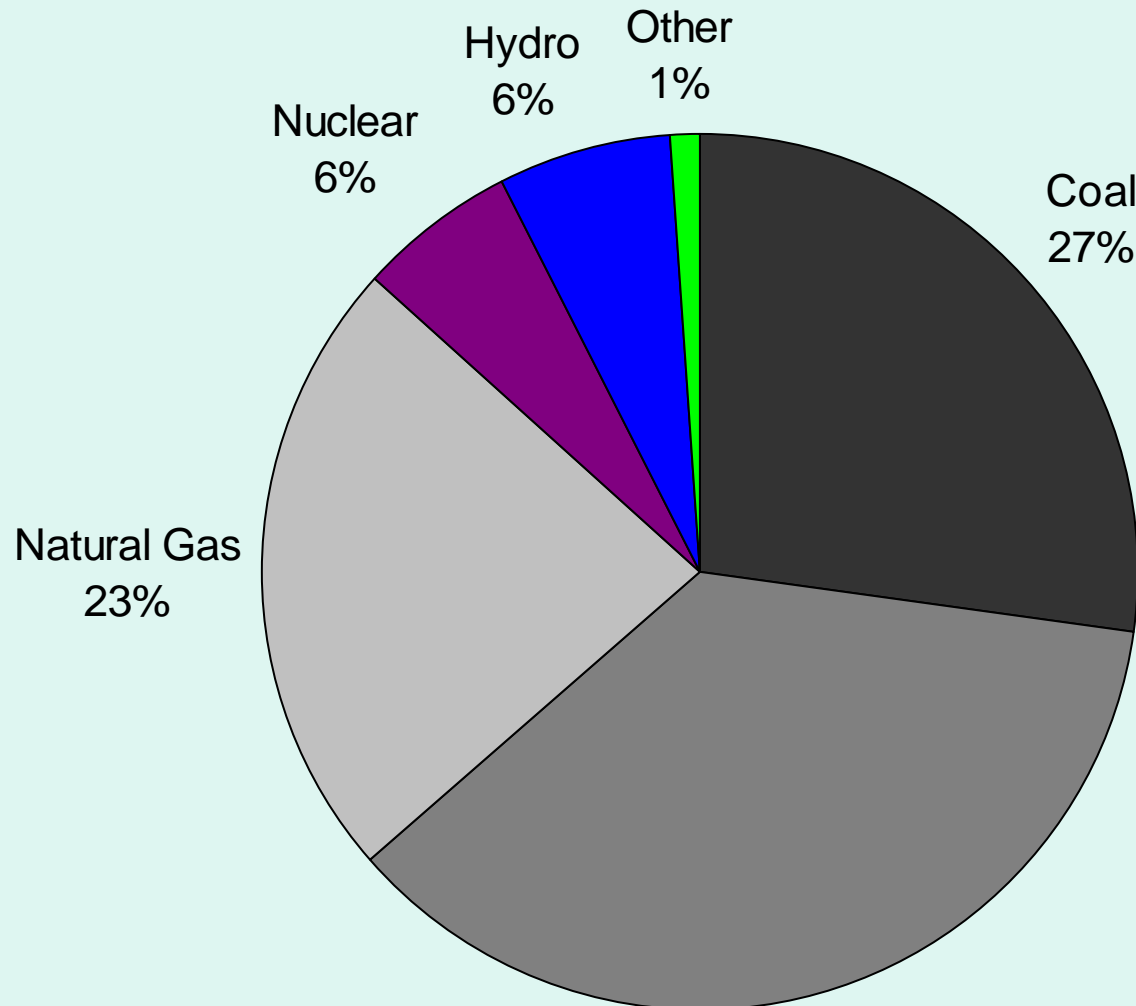


Absaloko coal mine, Montana



LA Freeway (Ansel Adams)

World Energy Sources

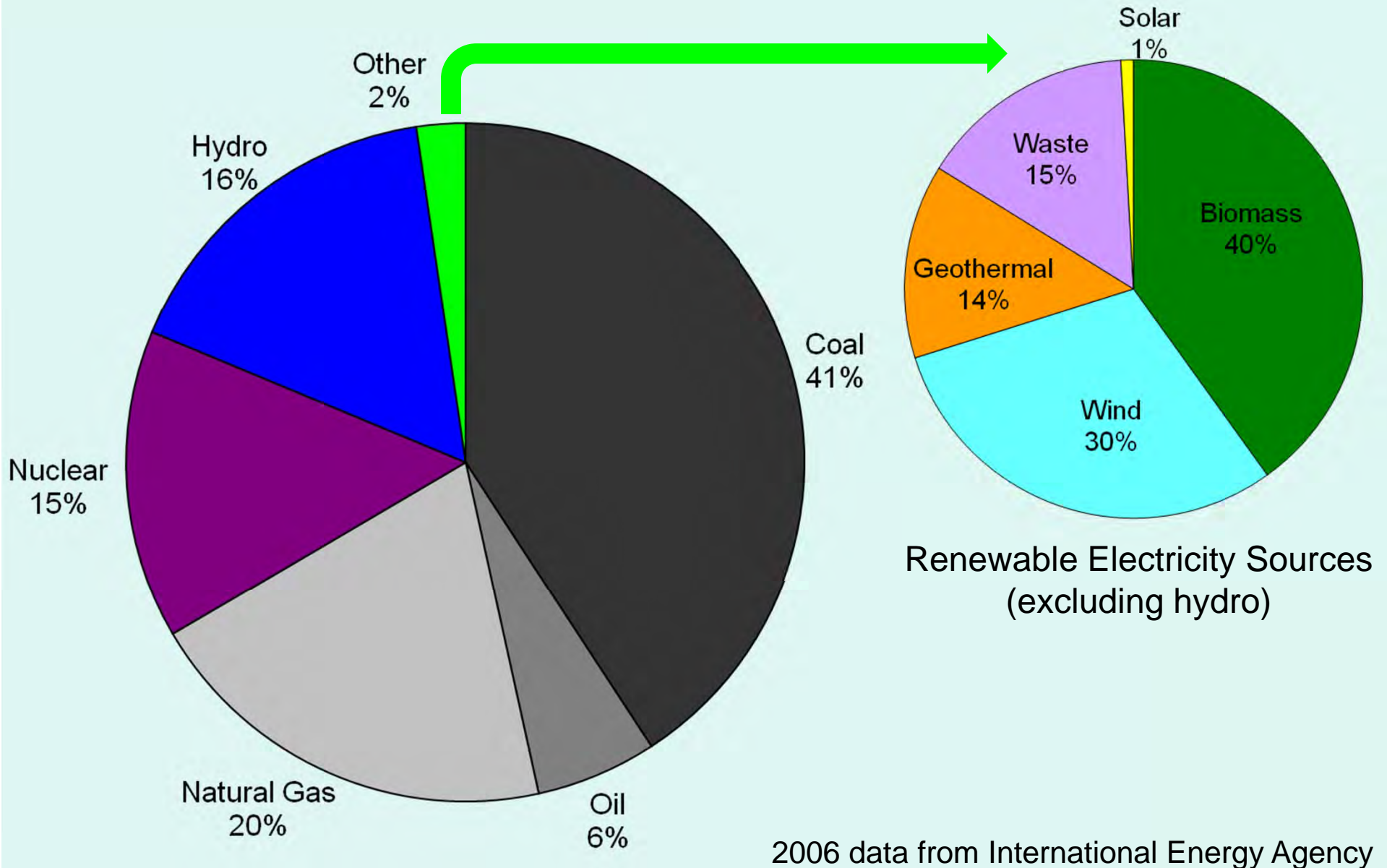


87% Fossil Fuels
(Coal, Oil, Natural Gas)

Oil
37%

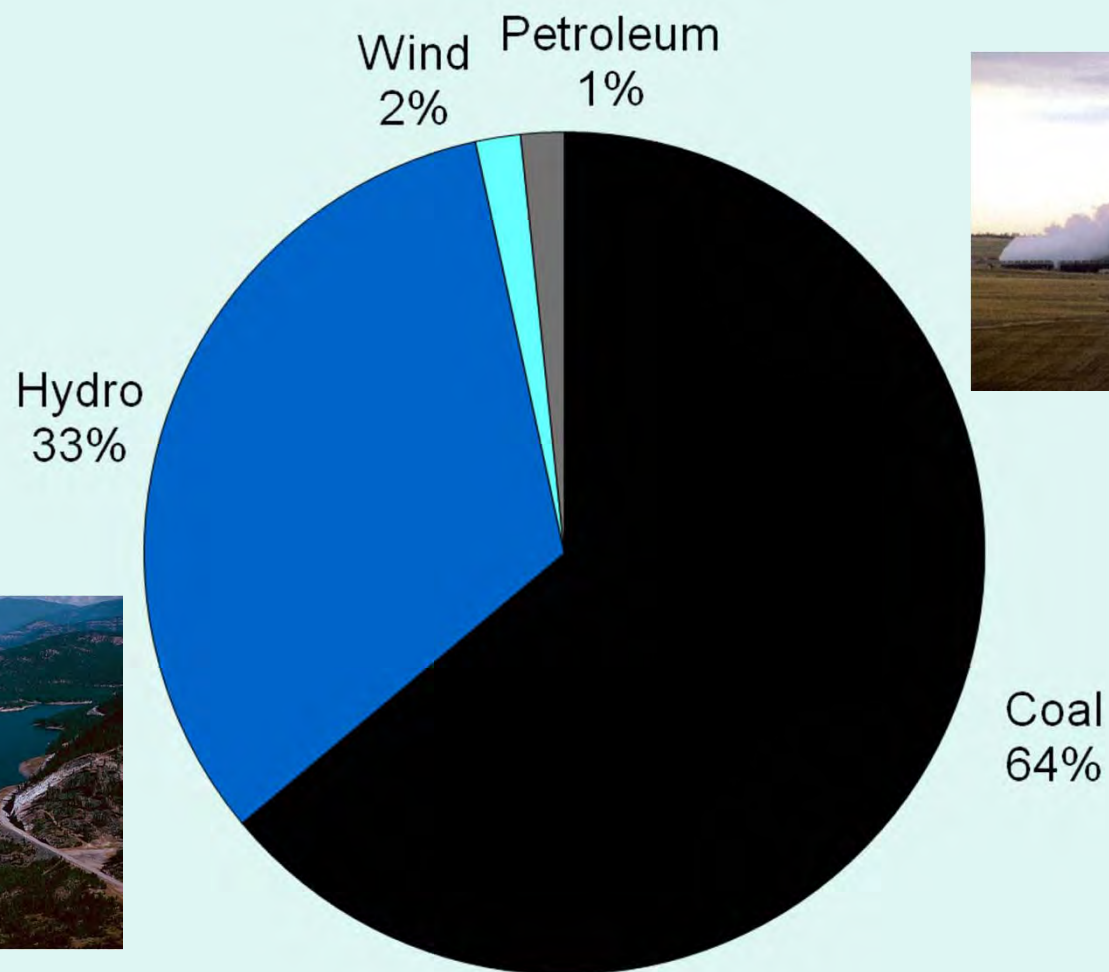
2006 data from International Energy Agency

World Electricity Sources



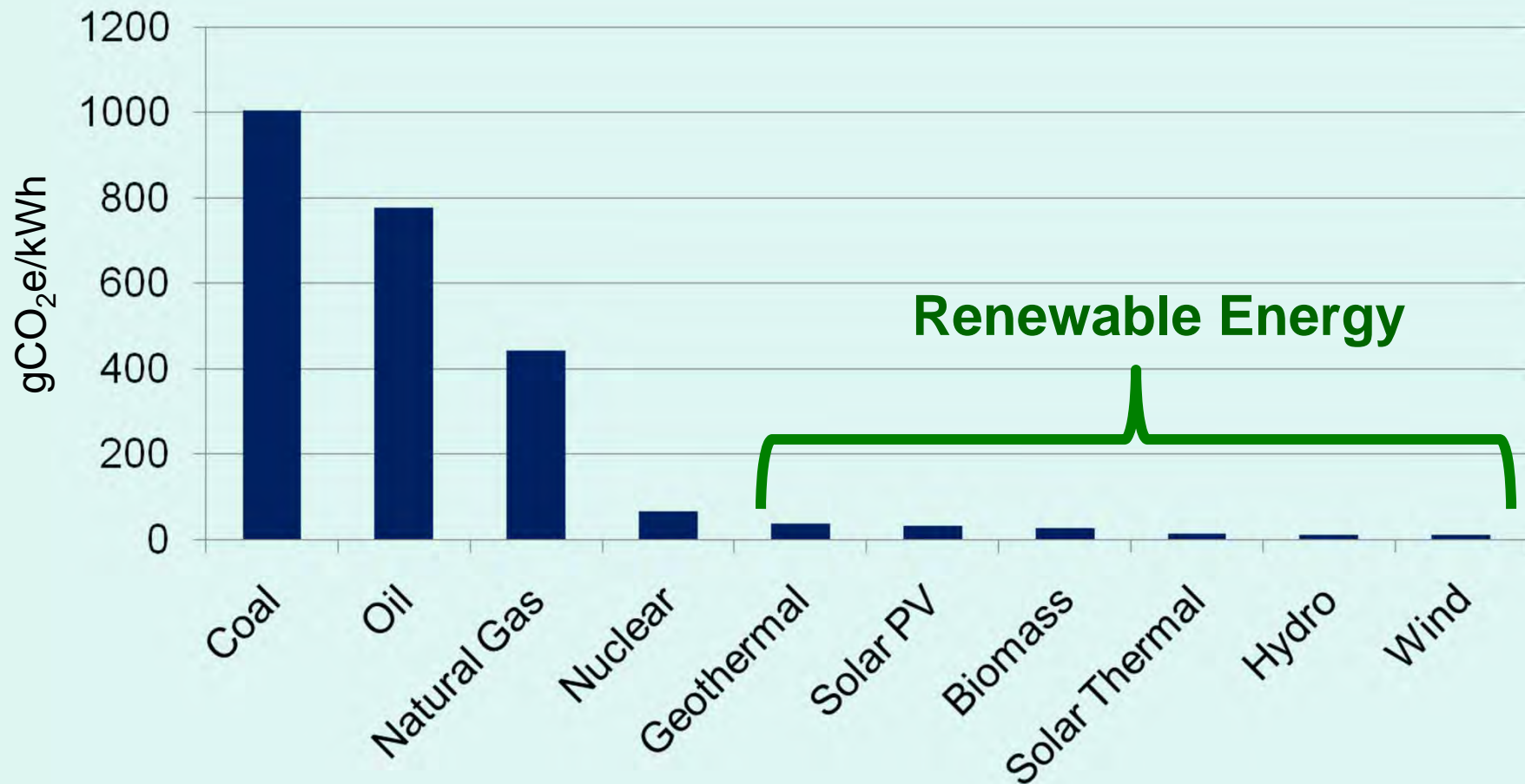
2006 data from International Energy Agency

Montana Electricity Sources



2007 data from "Understanding Energy in Montana" (DEQ/ETIC)

Lifecycle Greenhouse Gas Emissions for Electricity Generation



Based on Sovacool 2008

Other Benefits of Renewable Energy

- Reduces dependence on foreign energy sources
- Ease pressure on the electric grid (small systems)
- Reduce vulnerability to volatile fossil fuel prices
- Reduce air and water pollution
- Create jobs





All the world's wind contains
35 times more power than we need.



There is enough
wind in readily
accessible
locations to
power the world
5 times over.

Jacobson and Delucchi, 2009

All the world's wind contains
35 times more power than we need.

Turbine Technologies



Small Wind
10 kW

A small vertical-axis wind turbine with three blades, one of which is yellow, mounted on a tall, thin tower against a clear blue sky.



Big Wind
1.5 MW

A large horizontal-axis wind turbine with three white blades, standing in a grassy field under a blue sky with scattered clouds. Other smaller turbines are visible in the distance.



Really Big Wind
7 MW

A diagram of a large horizontal-axis wind turbine with three blades. To its left is a silhouette of the Statue of Liberty for scale. A vertical dimension line indicates the turbine's height is 126.3 m, and another vertical dimension line indicates the Statue of Liberty's height is 93 m. A dashed circle outlines the rotor area.

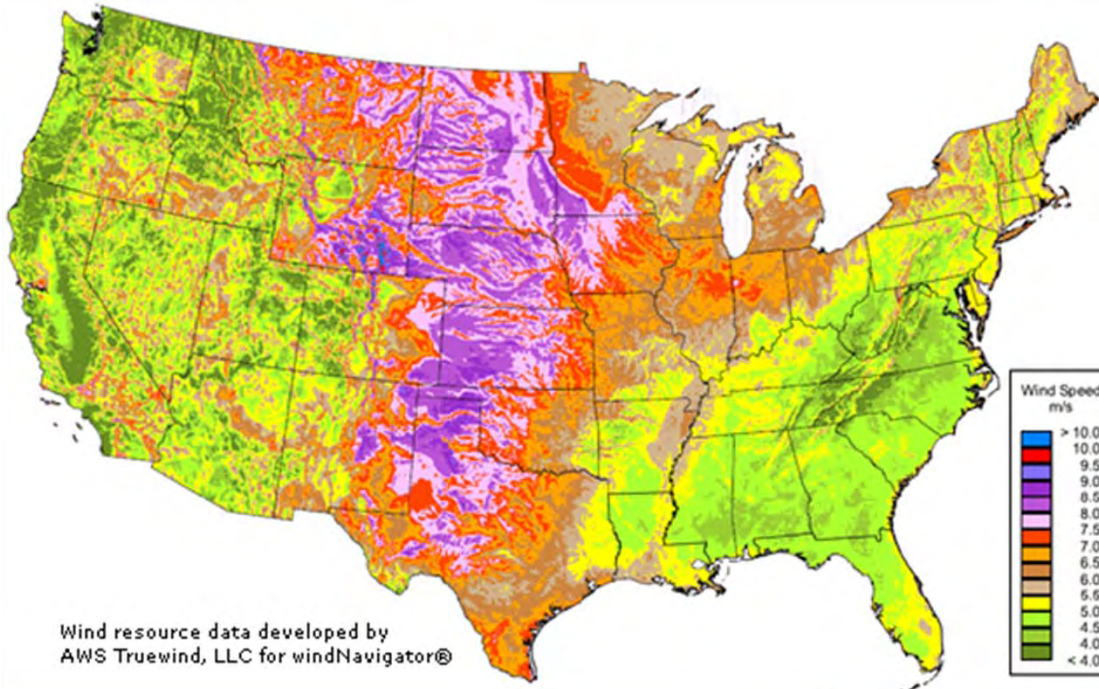


Vertical Axis

Two images of vertical-axis wind turbines. The left image shows a large, white, teardrop-shaped turbine with a tall tower and a curved blade. The right image shows a smaller vertical-axis turbine with three curved blades.

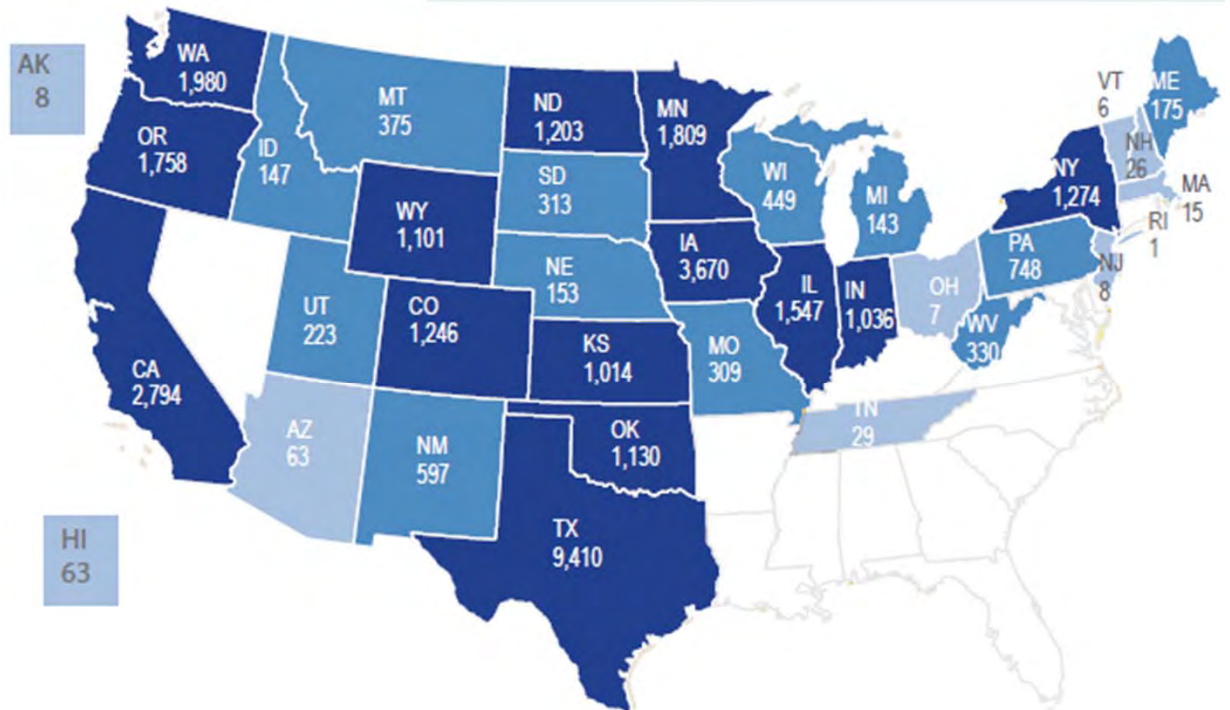
Improving Technology





Montana wind resource ranks among the top 5 in the nation...

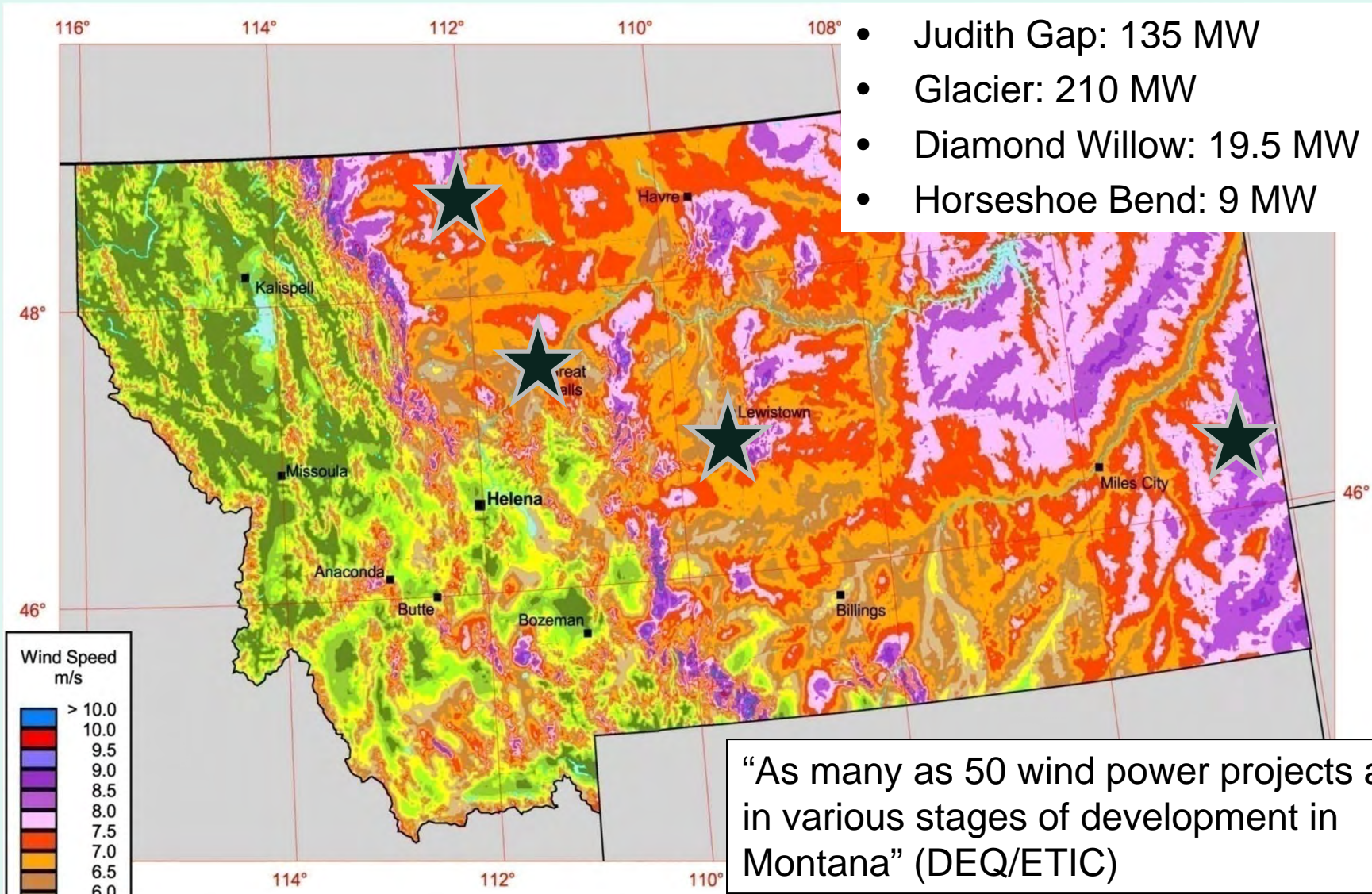
...but we rank 18th in terms of installed wind capacity



American Wind Energy Association 2009

Montana Wind Farms

- Judith Gap: 135 MW
- Glacier: 210 MW
- Diamond Willow: 19.5 MW
- Horseshoe Bend: 9 MW



“As many as 50 wind power projects are in various stages of development in Montana” (DEQ/ETIC)

Source: Wind resource estimates developed by AWS Truewind, LLC for windNavigator®. Web: <http://navigator.awstruewind.com> | www.awstruewind.com. Spatial resolution of wind resource data: 2.5 km. Projection: UTM Zone 11 WGS84.





All the sun striking earth
contains **8,000 times** more
power than we need.



All the sun striking earth contains **8,000 times** more power than we need.

There is enough solar radiation in readily accessible locations to power the world **50 times over.**

Jacobson and Delucchi, 2009

Solar Photovoltaic Energy

Eureka, Montana: 2.1 kW

Photo: Lincoln Electric Co-op/Thirsty Lake Solar



There are more than 800
grid-tied solar PV
installations in Montana

Victor, Montana: 7.9 kW

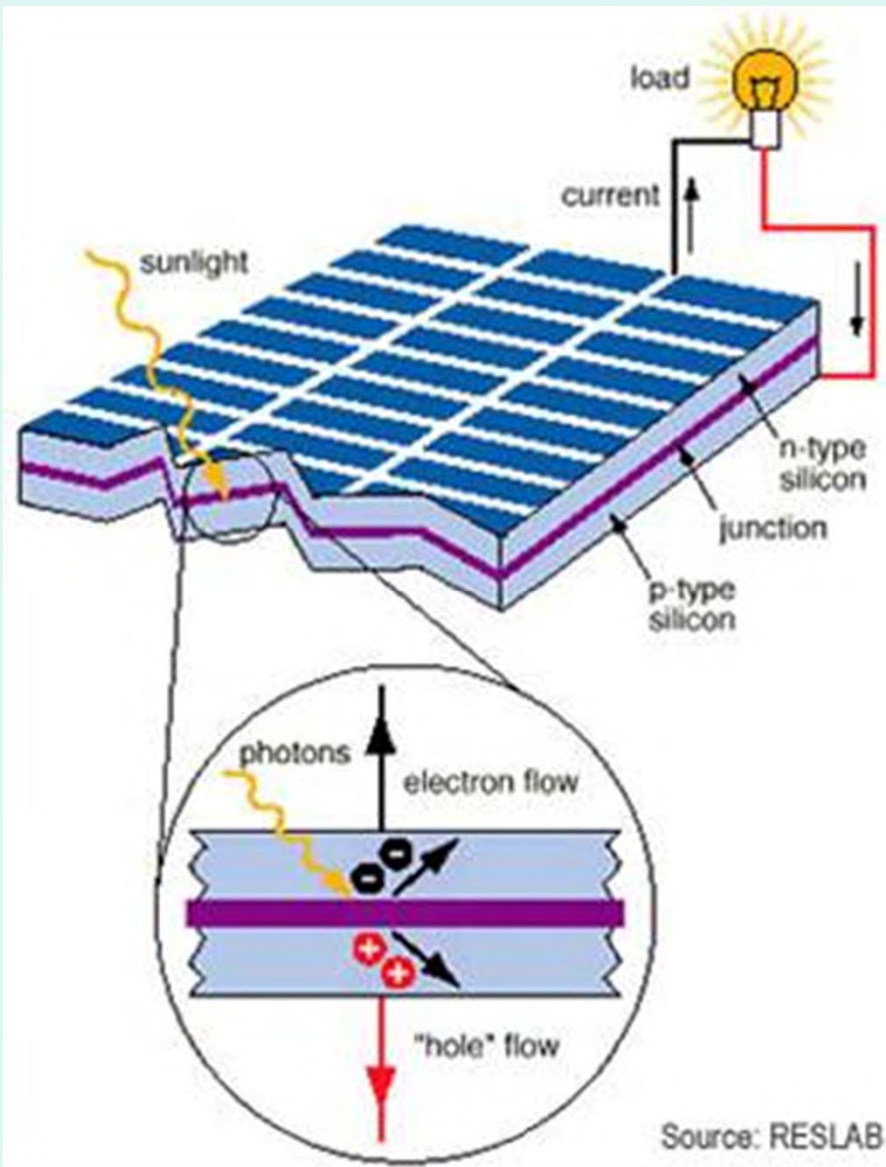
Photo: Sunelco



Waldpolenz, Germany: 40 MW



Photovoltaic Technologies

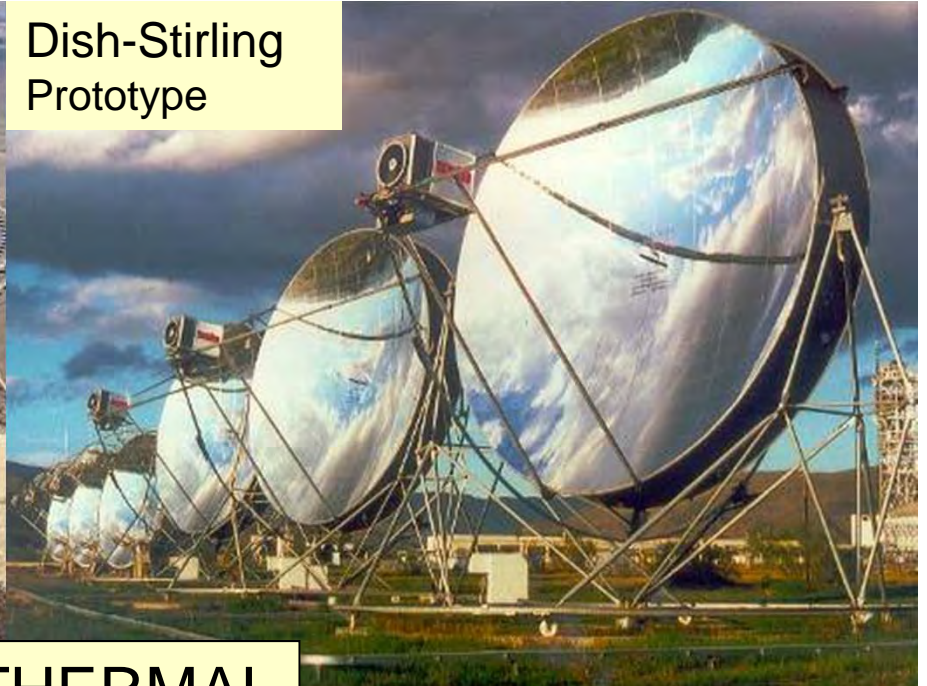


- **First Generation: crystalline silicon**
 - Market share: 86%
 - Typical efficiency: 13-18%
- **Second Generation: thin-film**
 - Market share: 14%
 - Typical efficiency: 6-10%
 - Cost: 10-30% below crystalline silicon

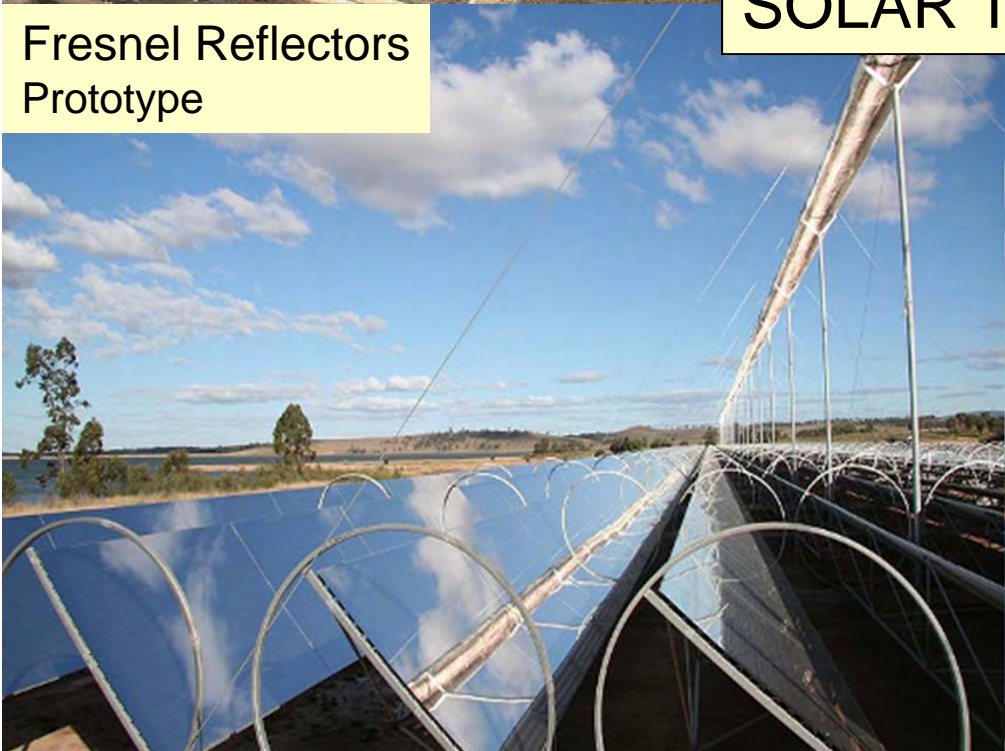
Solar Power Towers
Seville, Spain



Dish-Stirling
Prototype



Fresnel Reflectors
Prototype



SOLAR THERMAL

Parabolic Trough
SEGS, California



Solar Thermal Power Plants in California

Nearly 4,000 MW Approved;
up to 20,000 MW Proposed

**SEGS, 354 MW
(completed 1991)**

Victorville 50 MW solar trough

Genesis, 250 MW solar trough

Beacon, 250 MW solar trough

Abengoa, 250 MW solar trough

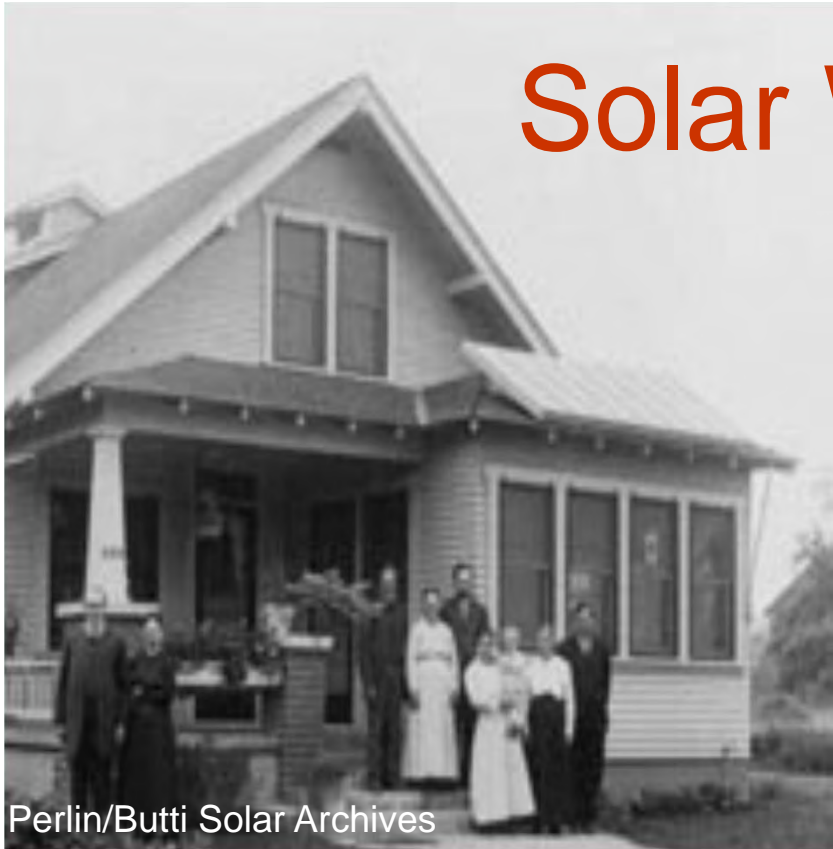
Calico, 664 MW Stirling engine

Ivanpah, 370 MW solar tower

Solar Millennium Blythe, 1,000 MW solar trough

Imperial Valley, 709 MW Stirling engine

Solar Water Heating

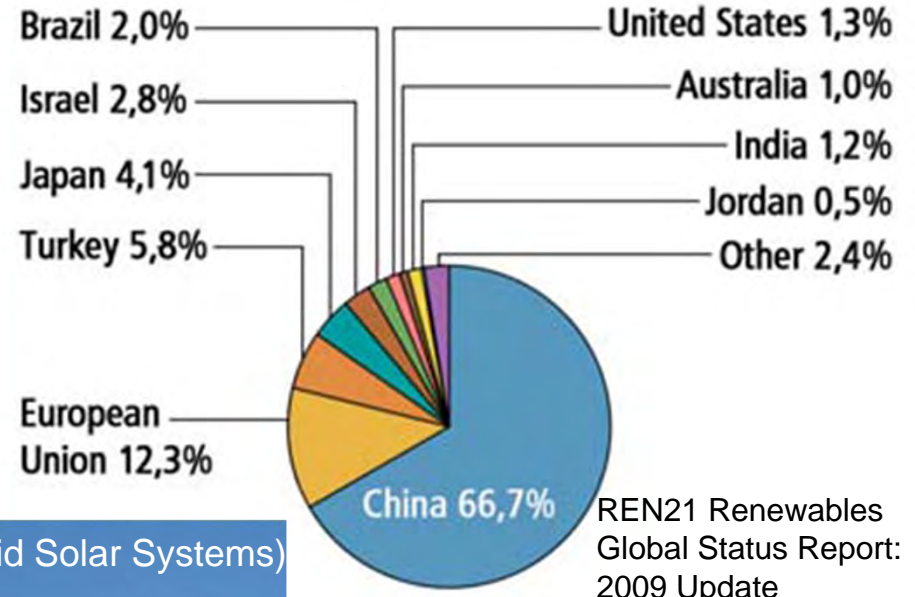


Perlin/Butti Solar Archives

Residential solar water heating system near Bozeman (Liquid Solar Systems)



Share of Solar Hot Water/Heating Capacity Existing, Top 10 Countries, 2007



REN21 Renewables
Global Status Report:
2009 Update

Total = 126 gigawatts-thermal

Geothermal Energy

Thermal Applications: space heating, water heating, hot springs

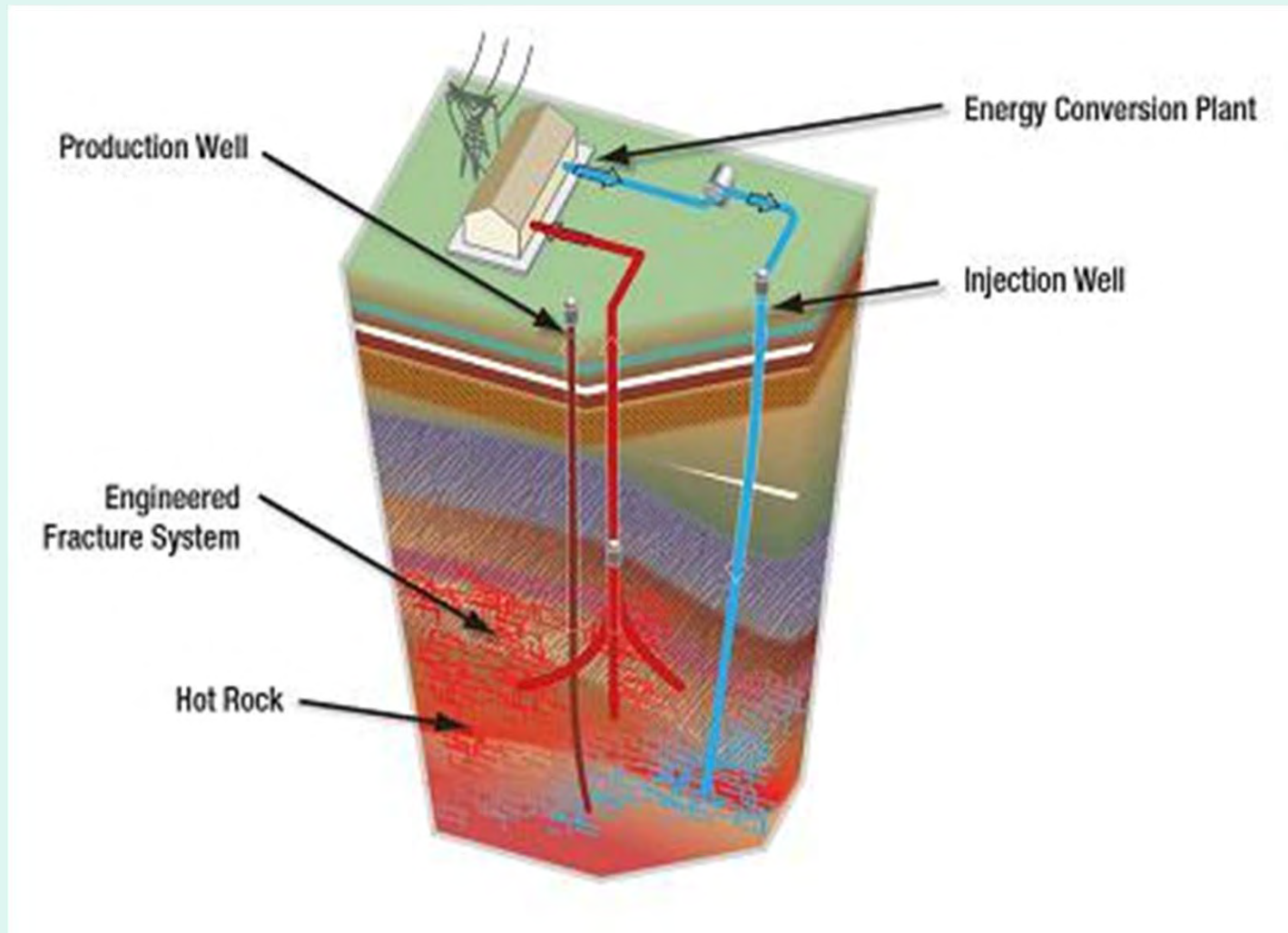
Power Plants: Dry steam, Flash steam, Binary cycle

Montana has 50 geothermal areas and 15 high-temperature sites



The Geysers in California: 725 MW, the world's largest geothermal power plant

Enhanced (Engineered) Geothermal Systems



Source: U.S. Department of Energy Geothermal Technologies Program_

Geothermal Heat Pumps

Closed Loop Systems

Horizontal

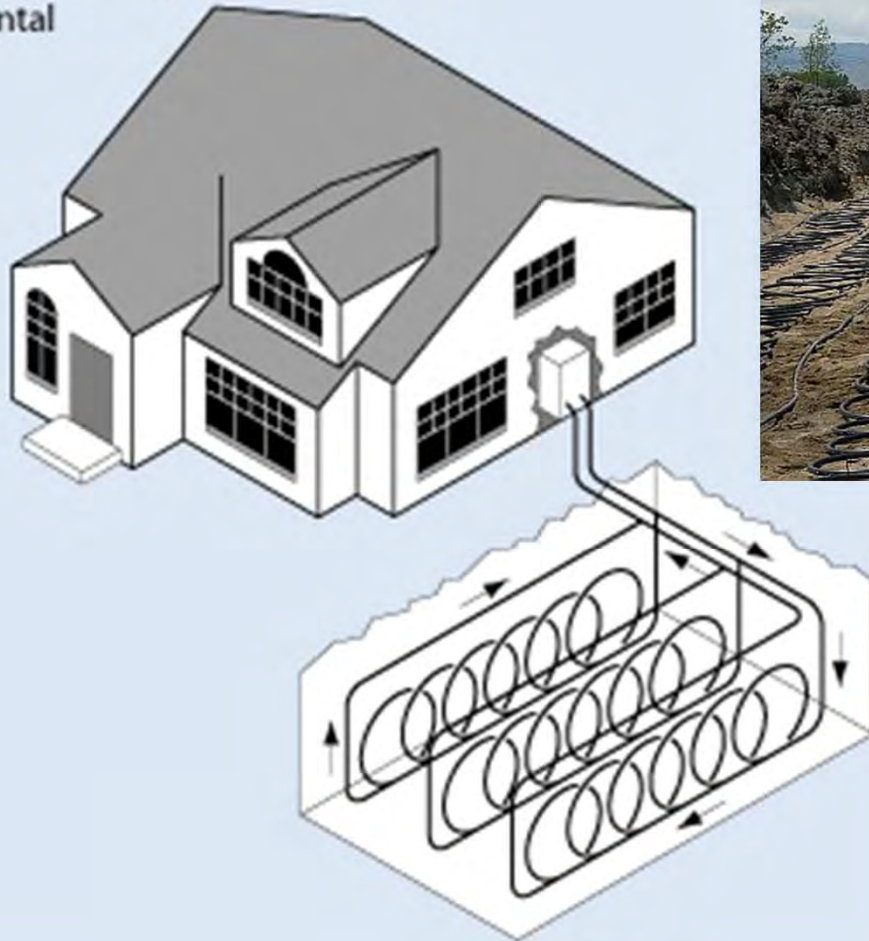


Photo: Intermountain Heating, Helena

Biomass Energy

Uses:

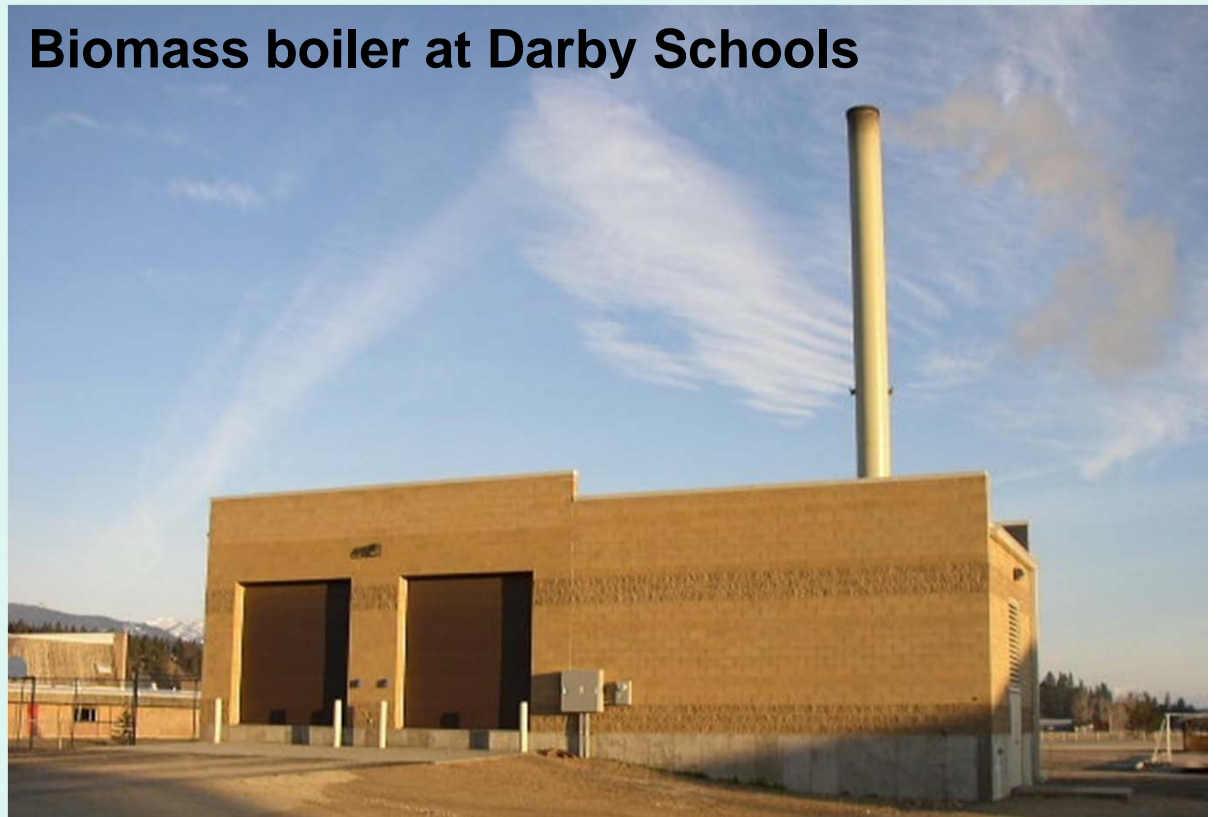
- Heating
- Electricity Generation
- Transportation Fuel

Biomass

Feedstocks:

- Forest residues
- Mill residues
- Crop residues
- Energy crops
- Animal waste
- Municipal waste

Biomass boiler at Darby Schools



Montana Biomass Potential?



Hydropower

Big dams provide 16% of worldwide electricity; 33% in Montana

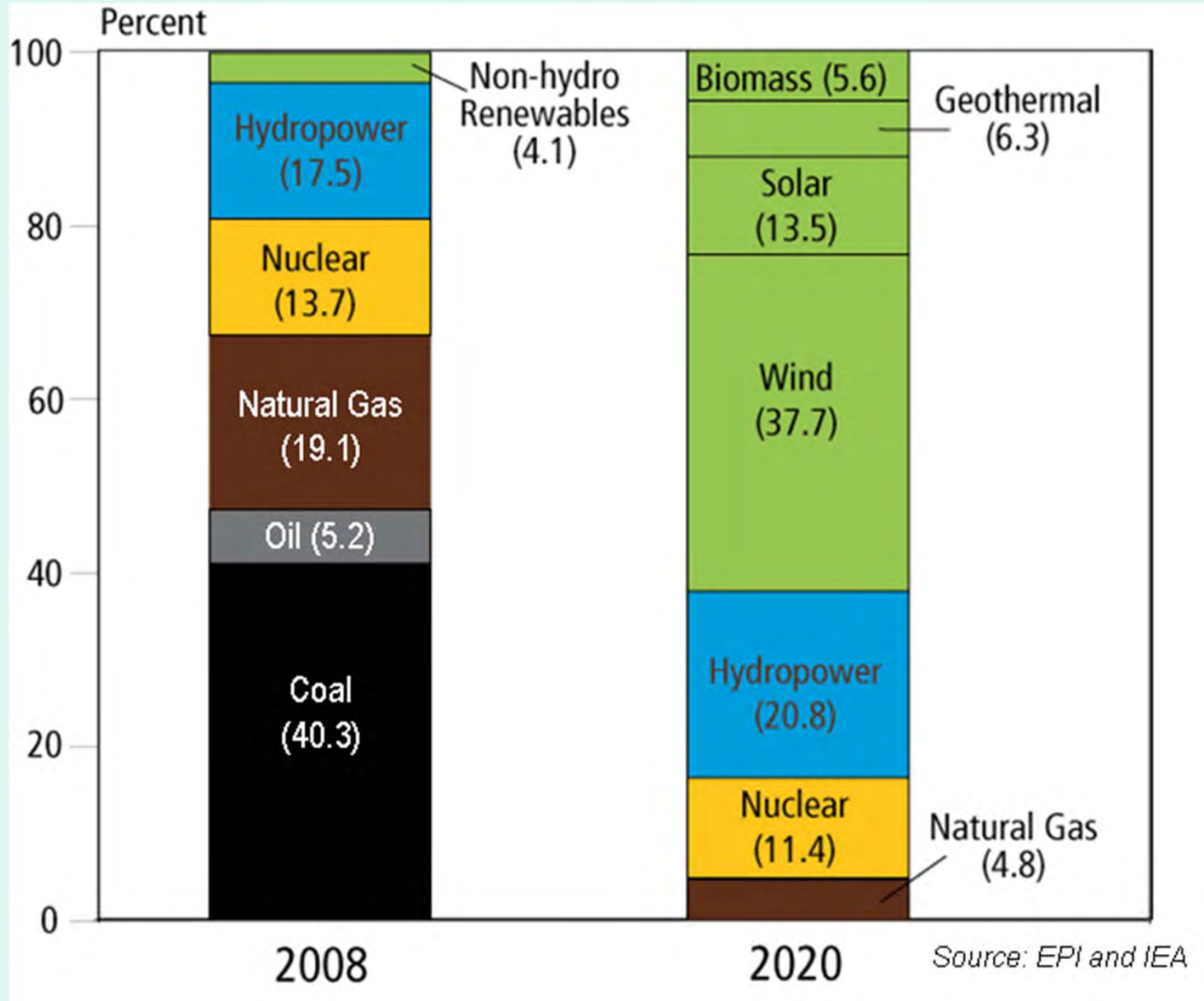
Other
hydropower
technologies:

- Run-of-the-river
- Ocean Power
 - Tidal
 - Wave
 - Thermal energy conversion

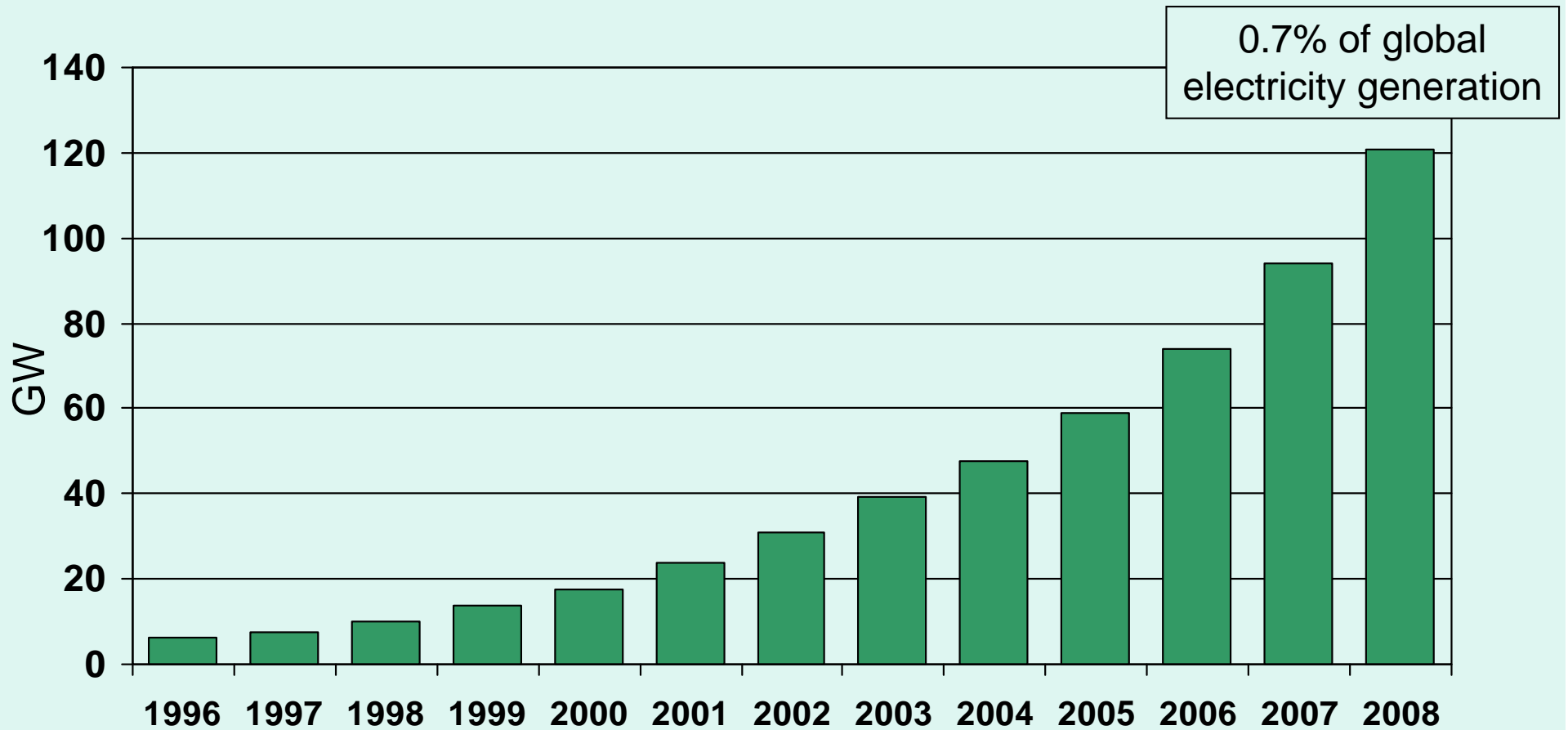


Libby Dam, Montana

Lester Brown: Plan B

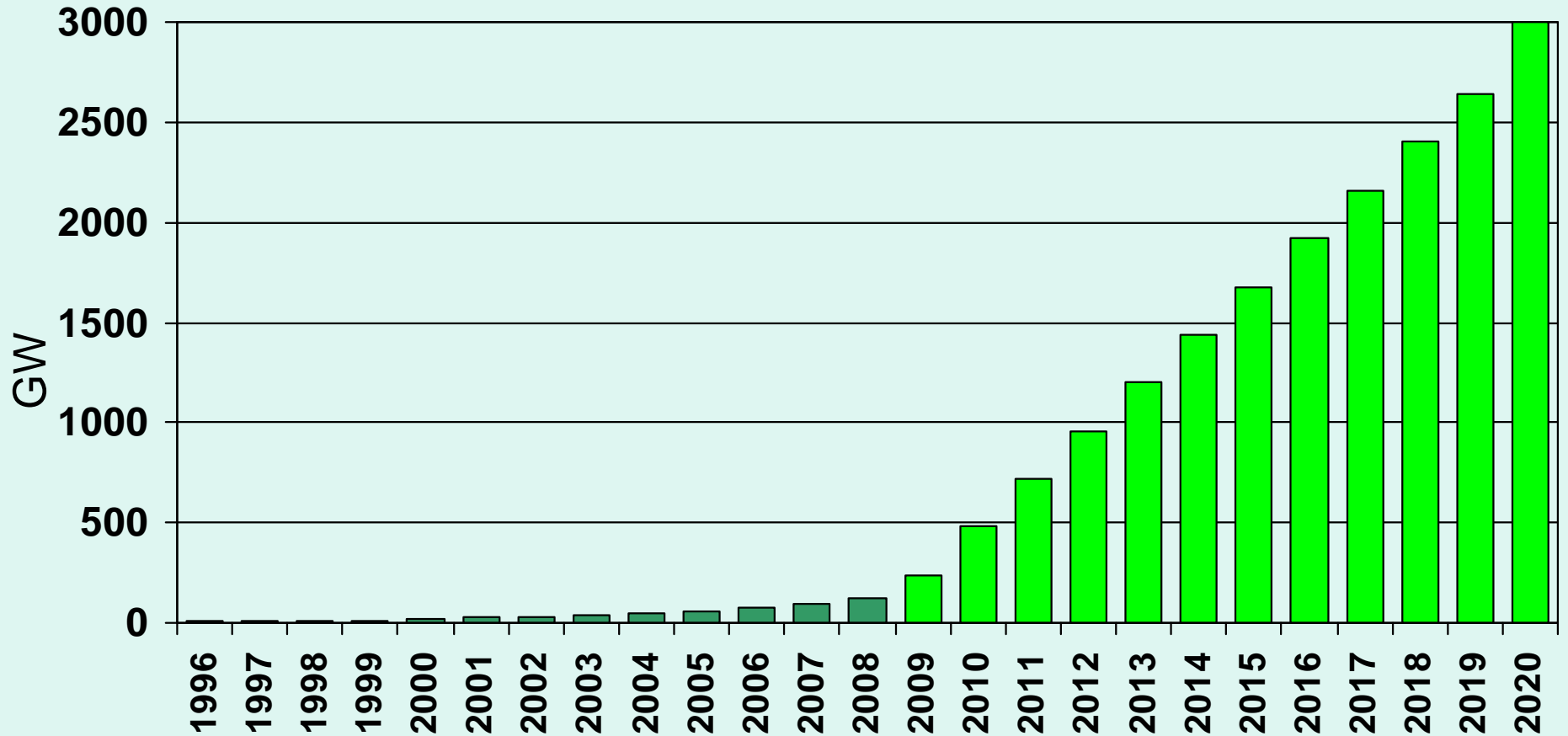


Global Wind Capacity



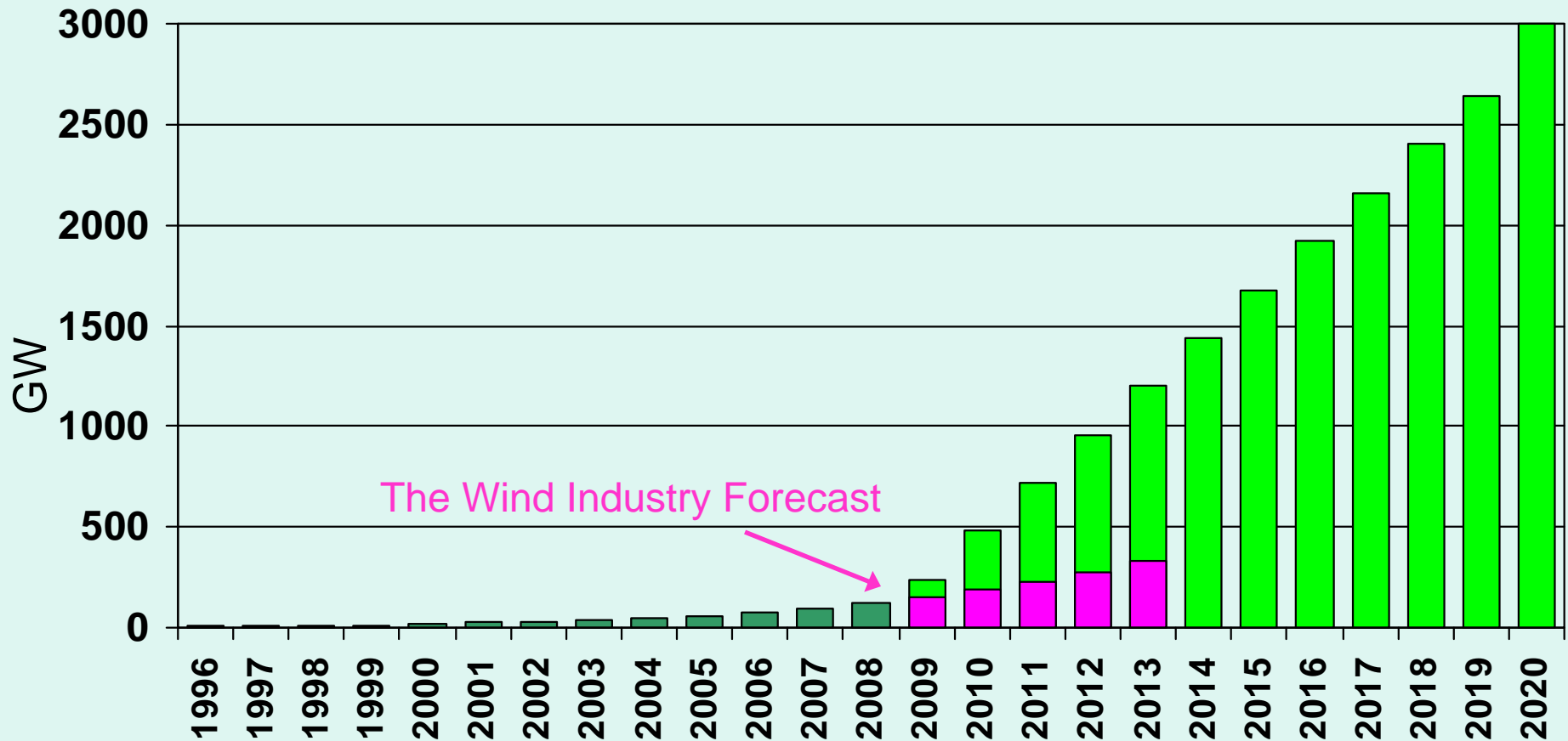
Data from Global Wind Energy Council

The Plan B Goal: 3,000 GW Wind in 2020



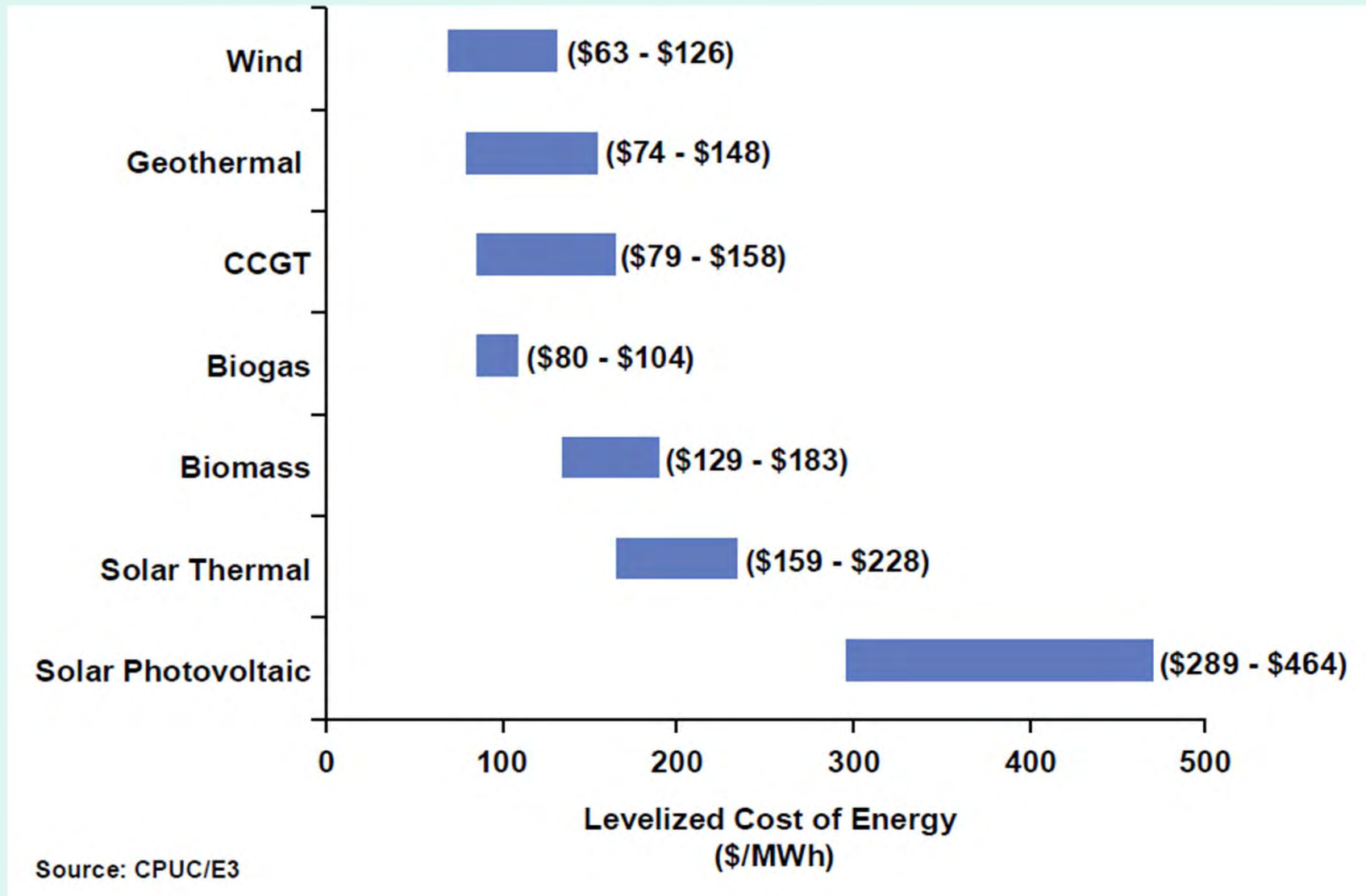
Data: Global Wind Energy Council, Lester Brown

The Plan B Goal: 3,000 GW Wind in 2020

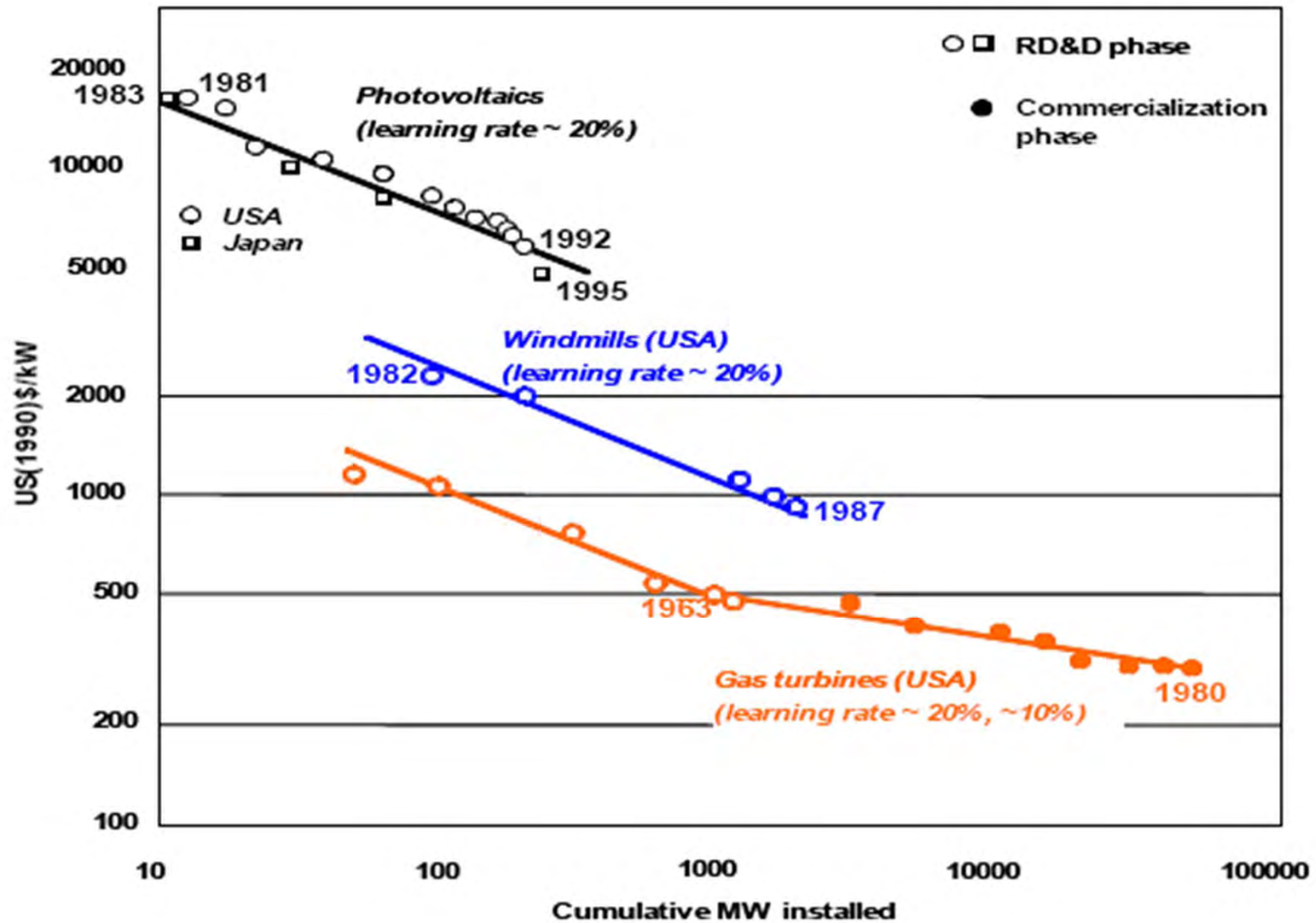


Data: Global Wind Energy Council, Lester Brown

Renewable Electricity Costs

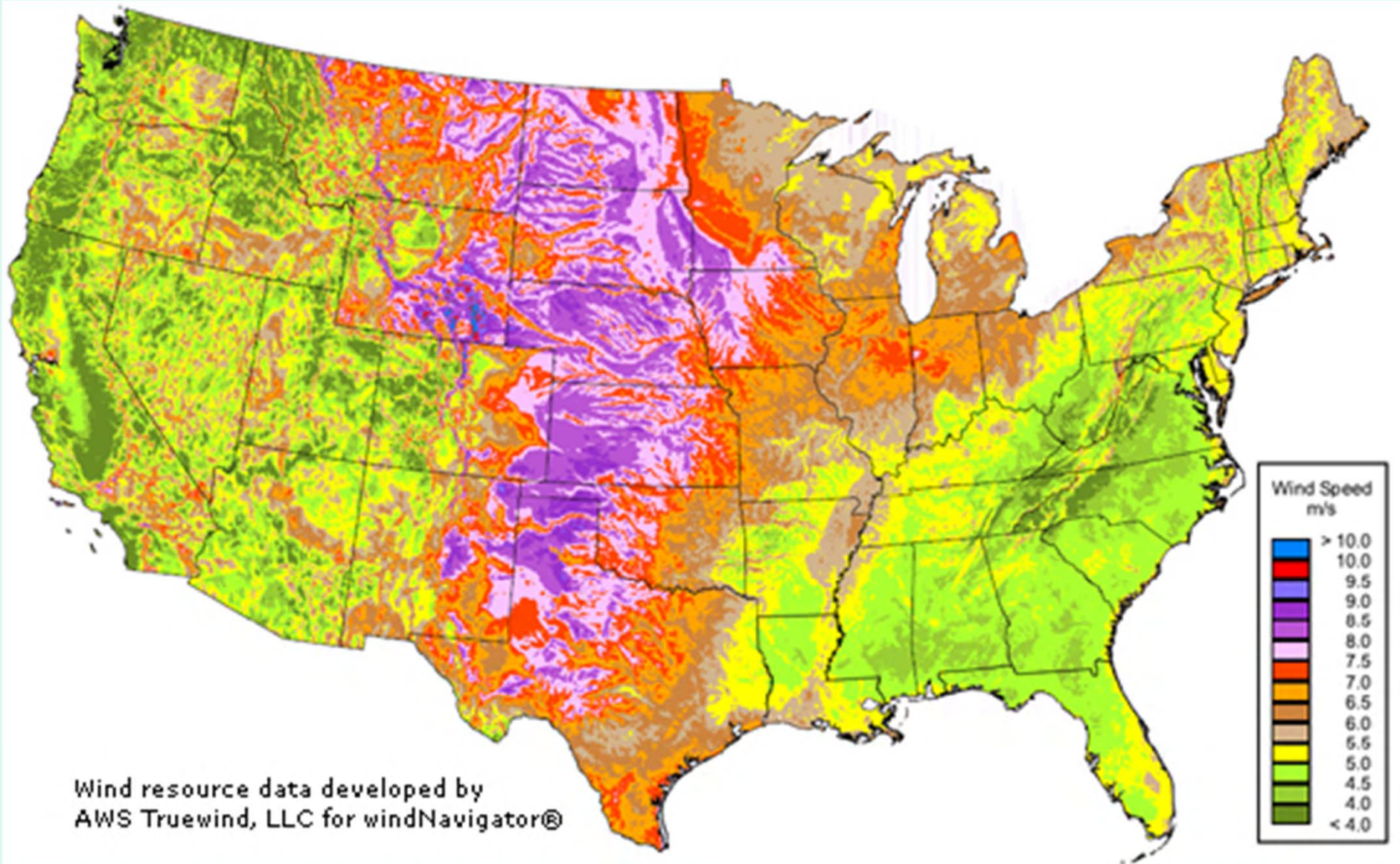


The Learning Curve



Source: Dan Kammen

US Wind Resource

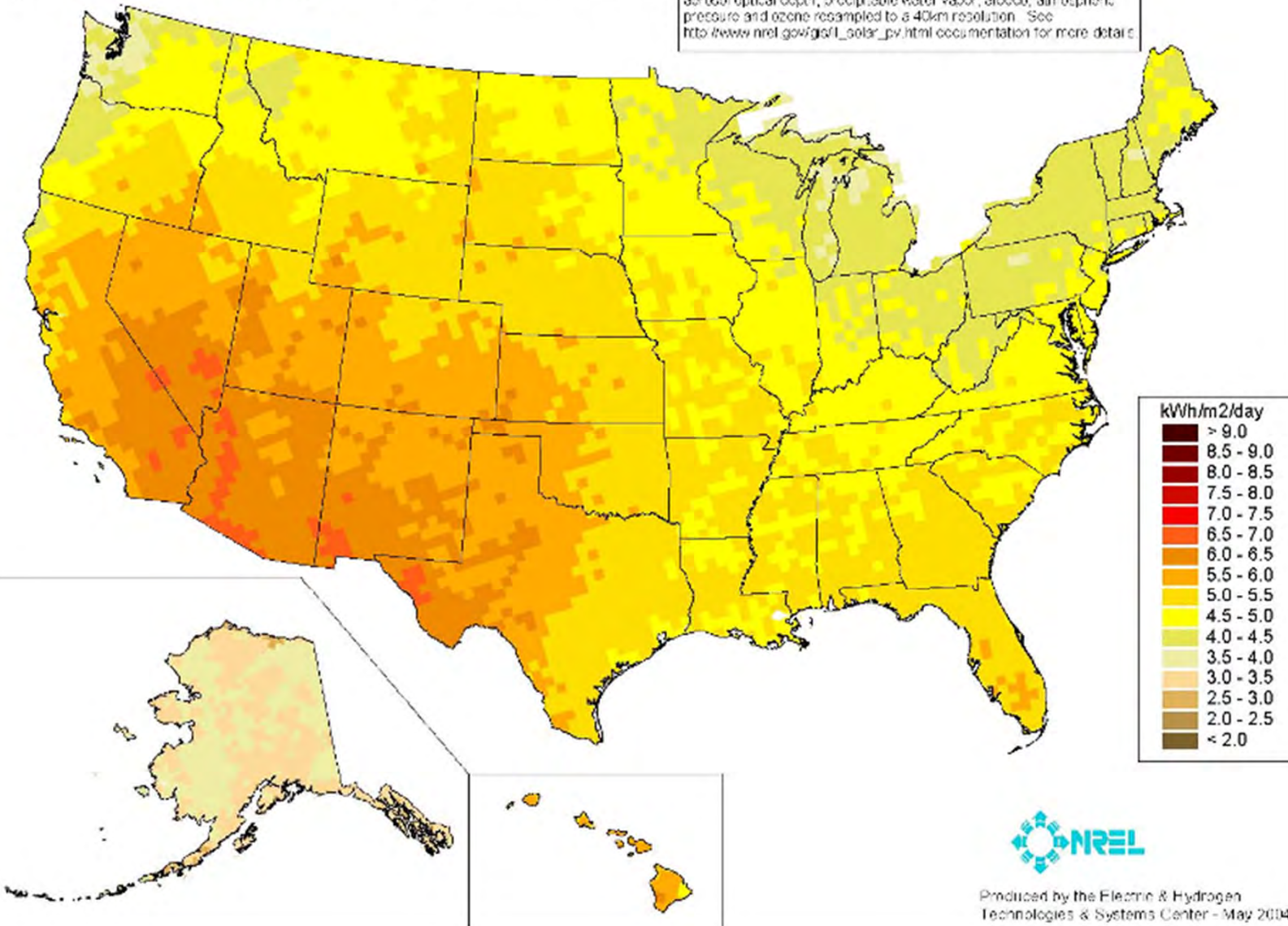


US Solar Resource

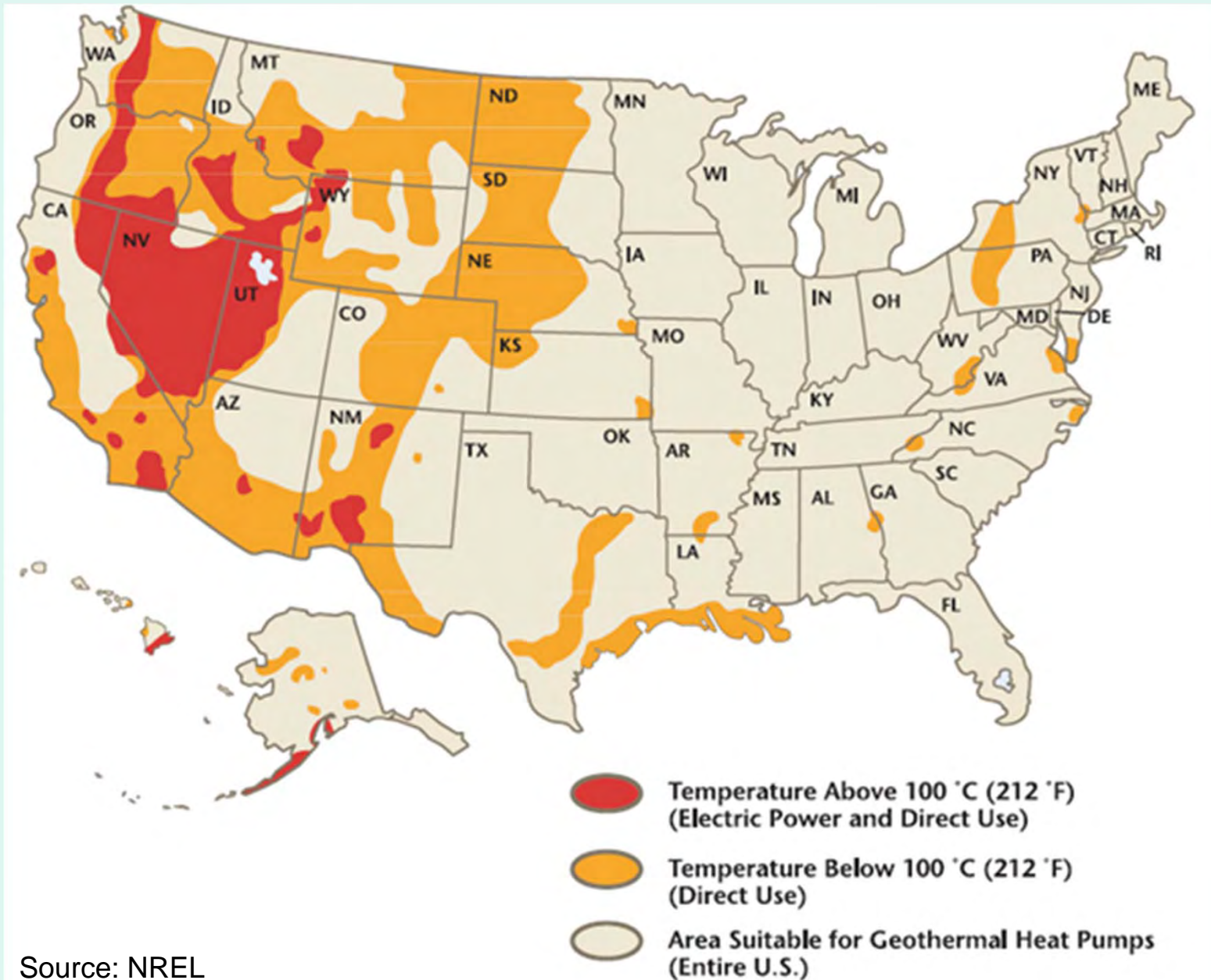
PV Solar Radiation
(Flat Plate, Facing South, Latitude Tilt)

Annual

Model estimates of monthly average daily total radiation using inputs derived from satellite and/or surface observations of cloud cover, aerosol optical depth, precipitable water vapor, albedo, atmospheric pressure and ozone resampled to a 40km resolution. See http://www.nrel.gov/gis/solar_pv.html documentation for more details.



US Geothermal Resource



Source: NREL



The Challenge: Transmission



- High cost
- Environmental and regulatory challenges
- Long construction time
- Modernization needed

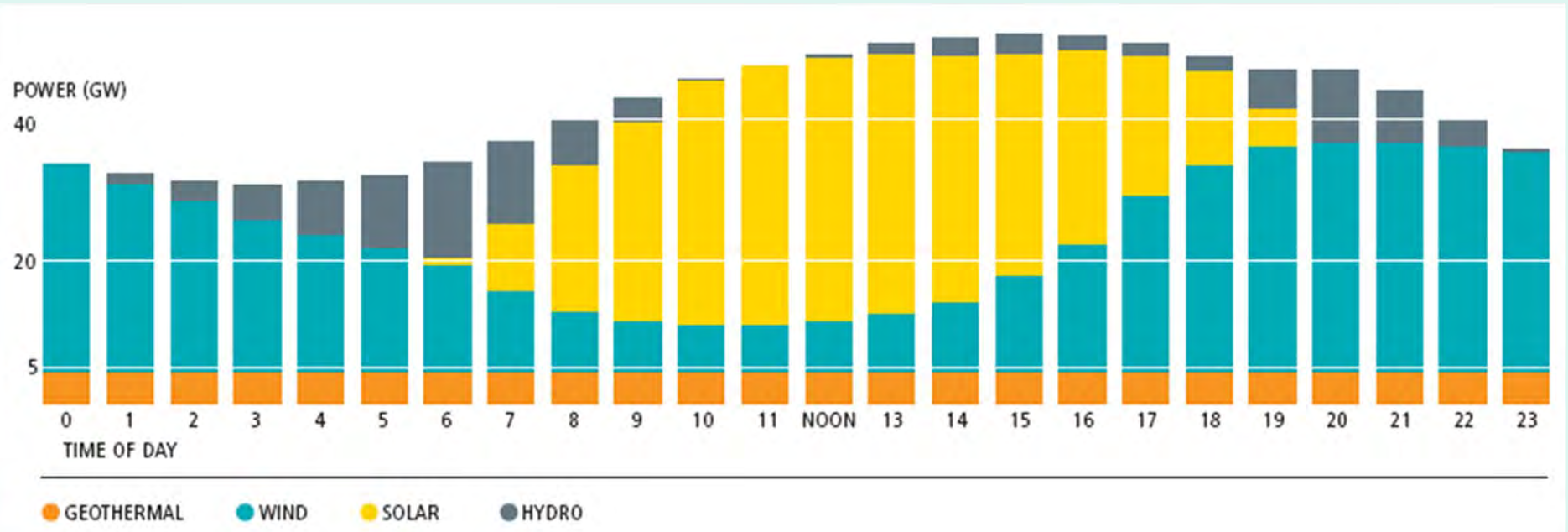
Proposed Montana Transmission Projects

- Montana-Alberta Tie Line: Great Falls to Alberta, Canada
- Mountain States Transmission Intertie : SW Montana to SE Idaho
- Chinook Transmission Project: Montana to Las Vegas
- Wind Spirit Project: Northern Plains to Nevada and California



Proposed Chinook Transmission Project
(image: MT Dept of Commerce)

The Challenge: Intermittency



“CALIFORNIA CASE STUDY: To show the power of combining resources, Graeme Hoster of Stanford University recently calculated how a mix of four renewable sources, in 2020, could generate 100 percent of California’s electricity around the clock, on a typical July day. The hydroelectric capacity needed is already in place.”

from Jacobson and Delucchi, 2009

The Challenge: Environmental Impacts

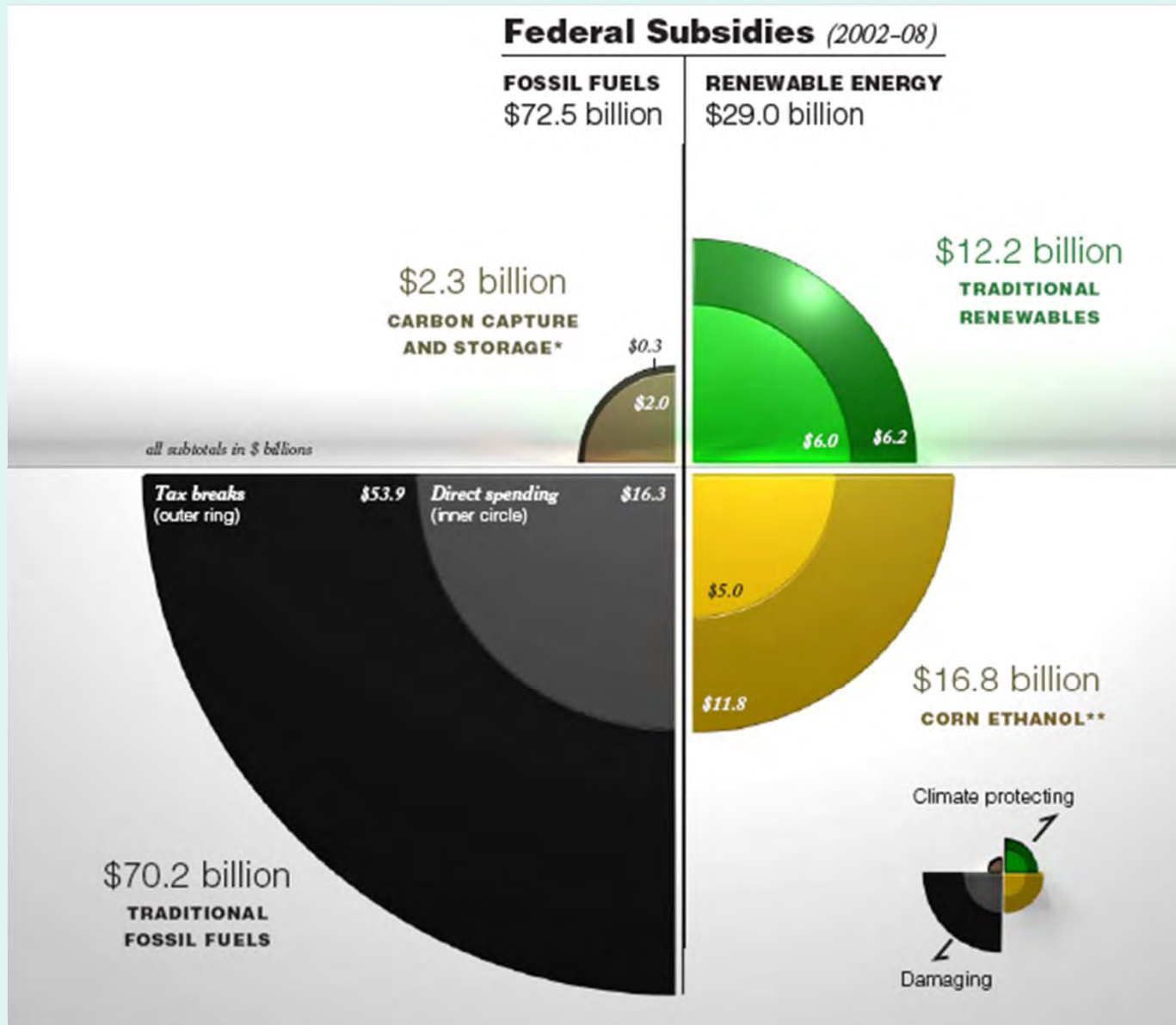


Dual land use: Rio Vista Wind Farm, California

Policies to Promote Renewables

- End Fossil Fuel Subsidies
- Put a Price on Carbon
- Renewable Portfolio Standard
- Financial Incentives
 - Net Metering
 - Feed-In Tariffs
 - Tax Credits

Fossil Fuel Subsidies



Source: Environmental Law Institute

Fossil Fuel Subsidies

G20 urges phasing out of fossil fuel subsidies

By Caren Bohan
TORONTO | Sun Jun 27, 2010 3:22pm EDT

(Reuters) - Leaders of the world's biggest economies will pledge on Sunday to phase out subsidies for "inefficient" fossil fuels, in a statement toughened at the last minute at the urging of the United States, Group of 20 sources said.

The G20 communique in Toronto calls for the "phase out over the medium term of inefficient fossil fuel subsidies that encourage wasteful consumption, taking into account vulnerable groups and their development needs," said the sources, who provided the language to Reuters.

The leaders also said they would review progress toward that goal at future summits. The sources said the United States had pushed to removed watered-down language from an earlier draft.

An earlier version of the statement referred to "voluntary, member-specific approaches" to getting rid of fossil fuel subsidies but made no mention of a review of the progress.

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[WRAPUP 6-G20](#)

World should eradicate fossil fuel subsidies: IEA



By Gerard Wynn
LONDON | Tue Nov 9, 2010 12:18pm EST

(Reuters) - Abolishing fossil fuel subsidies would boost the world's economy, environment and energy security, the International Energy Agency said on Tuesday, referring to a pledge made by G20 countries.

World leaders committed in Pittsburgh in 2009 to phase out, over the medium-term, fossil fuel subsidies which encouraged wasteful consumption. A G20 meeting in Seoul this week may update progress on the goal.

"Eradicating subsidies to fossil fuels would enhance energy security, reduce emissions of greenhouse gases and air pollution, and bring economic benefits," said the IEA, the energy watchdog to 28 industrialized countries, in its annual set-piece World Energy Outlook.

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[Fossil fuel subsidies across the world](#)
Tue, Nov 9 2010

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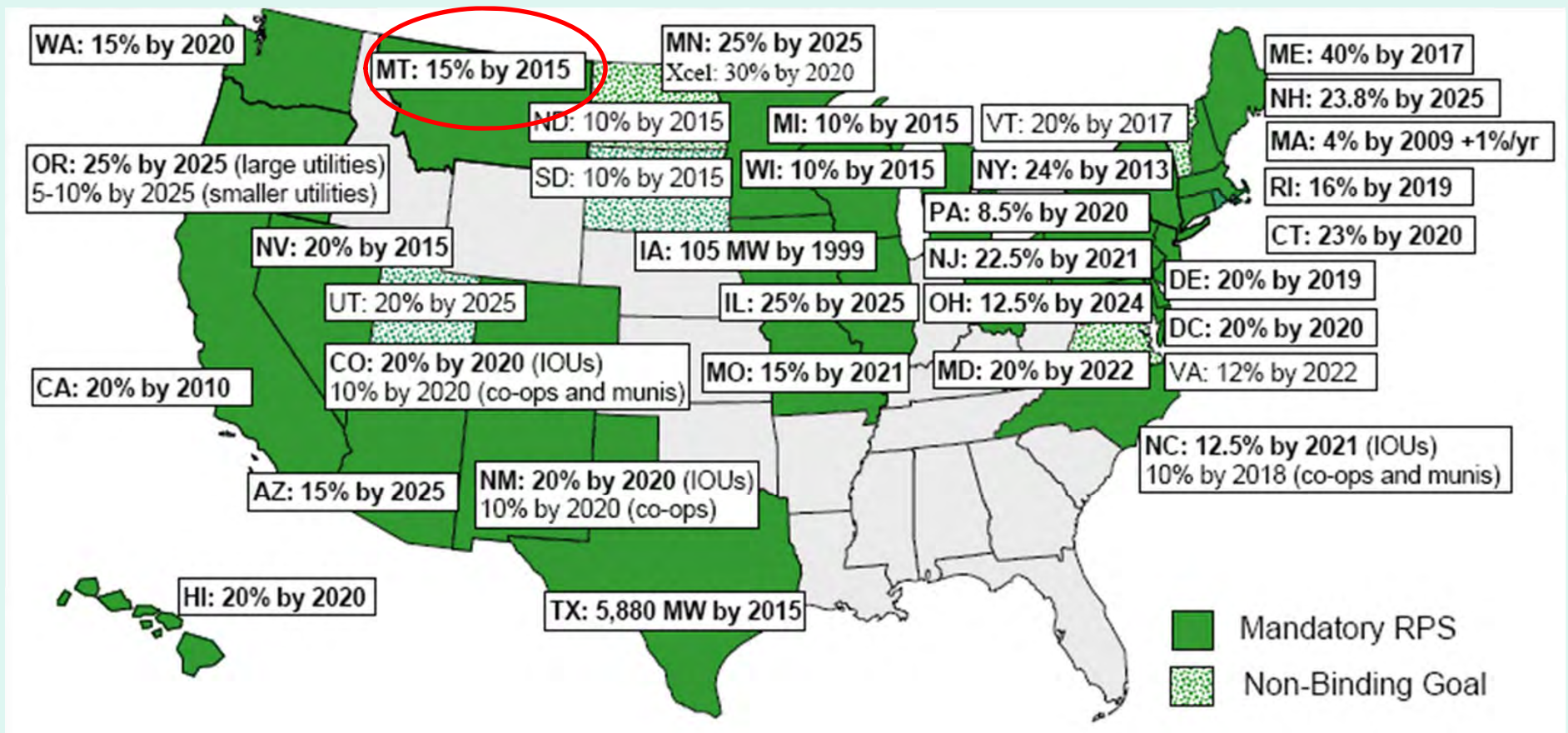
[Green Business »](#)

Putting a Price on Carbon

- The key to increasing renewable energy development
- Possible mechanisms: carbon tax, cap and trade, cap and dividend...

Renewable Energy Standard

Requirement on retail electricity providers (e.g. utilities) to supply a minimum percentage of their load with renewable energy.



Source: Renewable Portfolio Standards in the United States, Lawrence Berkeley National Laboratory 2008

Net Metering

- Requirement that utilities connect small renewable systems to the grid and “buy” excess power generated at the regular retail rate
- In Montana, net metering is available for NorthWestern Energy customers for systems up to 50 kW



50 kW solar system in Missoula (Oasis Montana)

Feed-In Tariffs

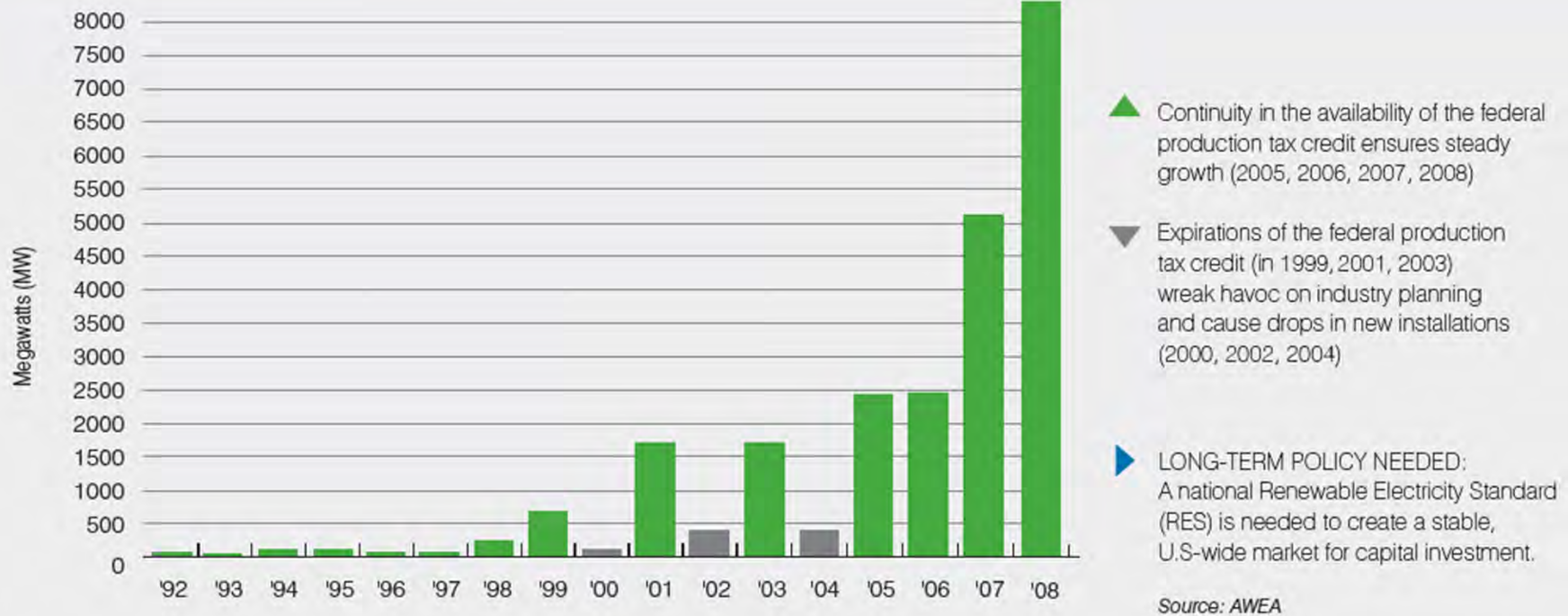
- Fixed, long-term above-market price to eligible renewable generators
- Common in Europe
 - Found by the European Commission to be the most successful policy mechanism for increasing renewable development

Wind Penetrations

Denmark	21%
Spain	12%
Germany	7%

Tax Credits Work

Annual Installed U.S. Wind Power Capacity



...but continuity is needed

What You Can Do

- Reduce your energy consumption
 - Replace your lightbulbs
 - Buy efficient appliances
 - Weatherize your house
- Invest in a renewable energy system
- Buy Green Power



Contact



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