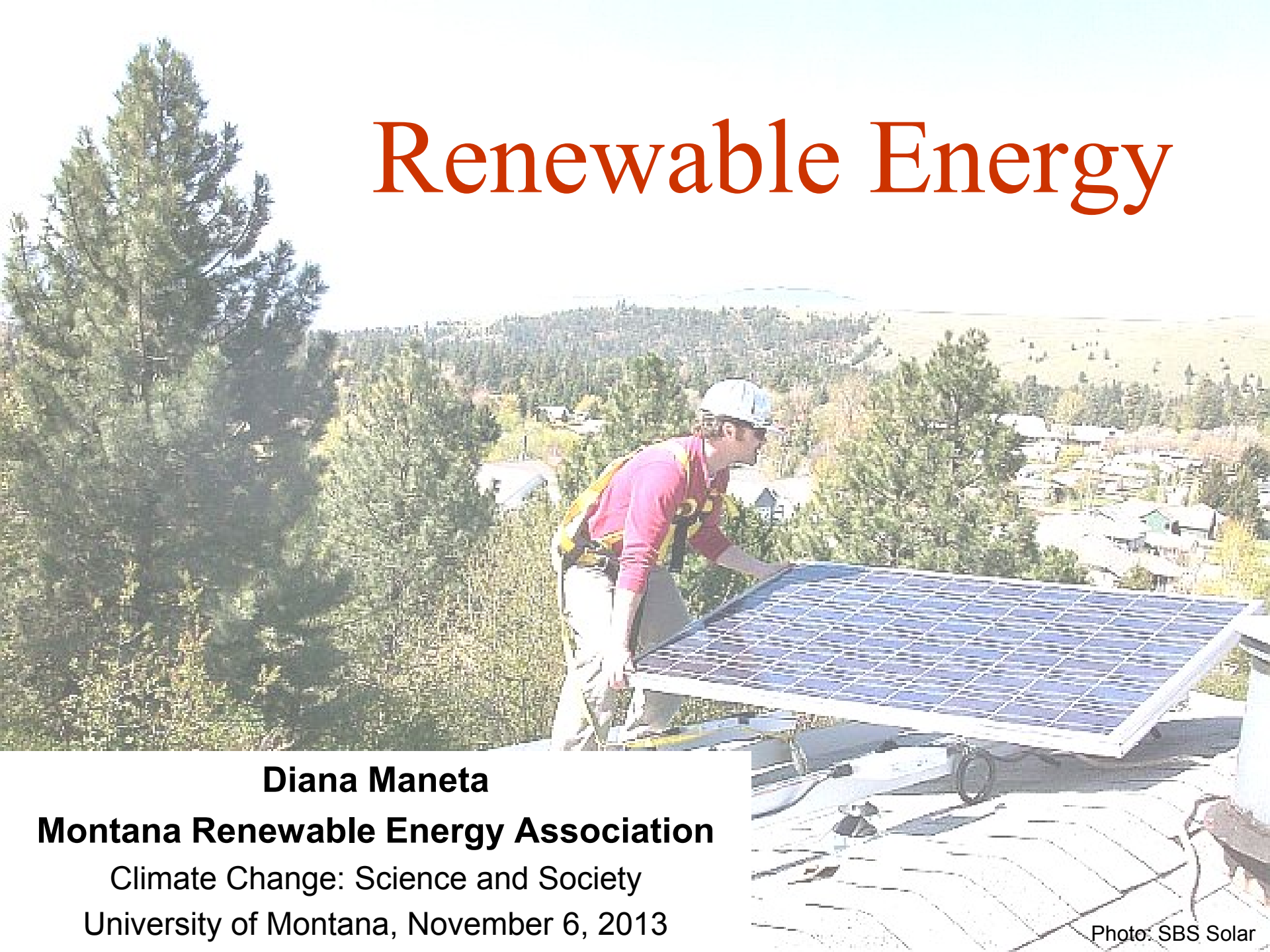


# Renewable Energy



**Diana Maneta**

**Montana Renewable Energy Association**

Climate Change: Science and Society

University of Montana, November 6, 2013

Photo: SBS Solar

# Climate Change and Our Energy System

---

“CO<sub>2</sub> concentrations have increased by 40% since pre-industrial times, ***primarily from fossil fuel emissions*** and secondarily from net land use change emissions.”

- IPCC 5<sup>th</sup> Assessment Report, 2013

## COAL



Colstrip power plant, Montana  
(image: Billings Gazette)

## OIL



Los Angeles Freeway  
(image: Ansel Adams)

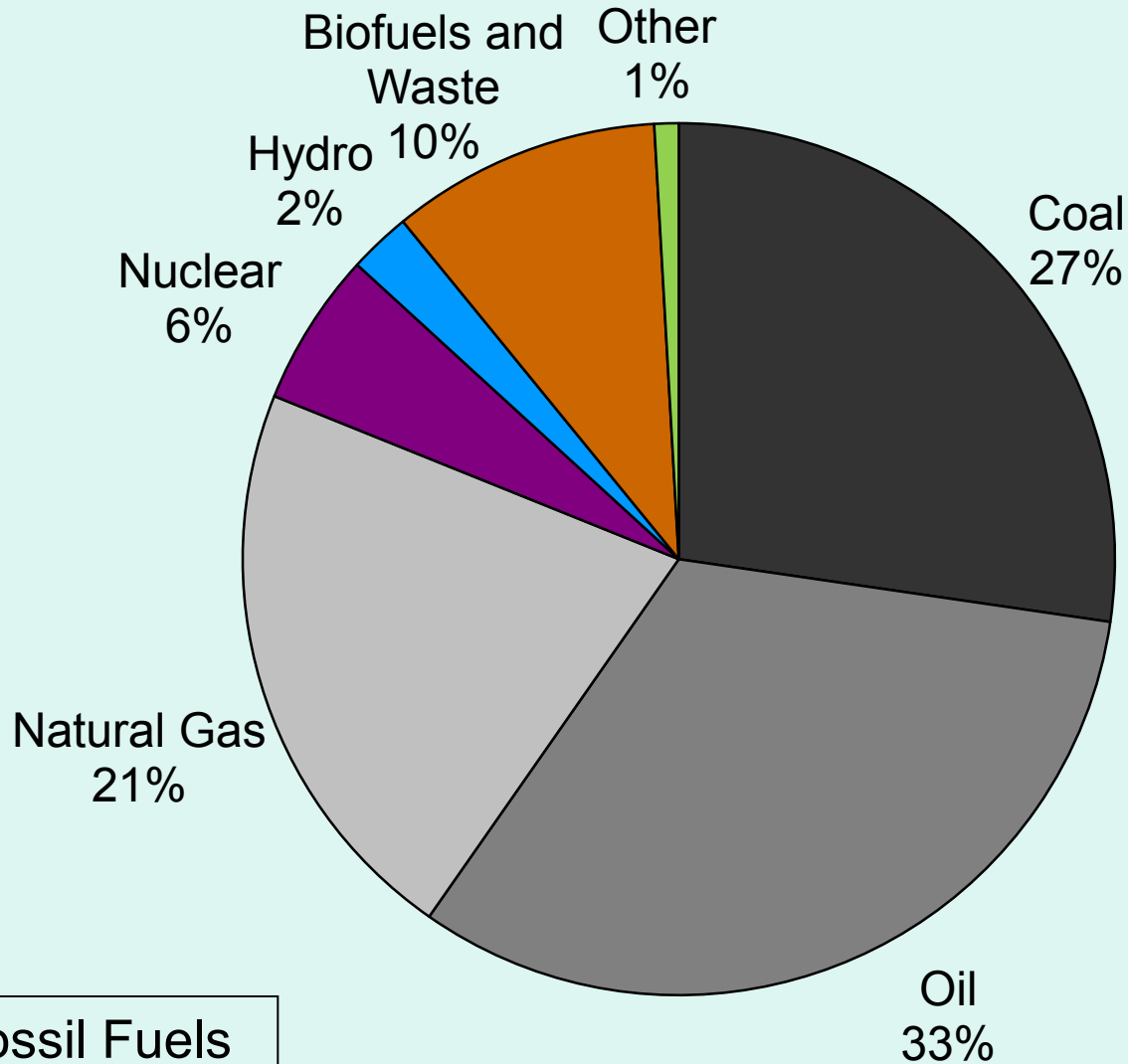
## NATURAL GAS



Drilling rig  
(image: StateImpact Pennsylvania)

# World Energy Sources

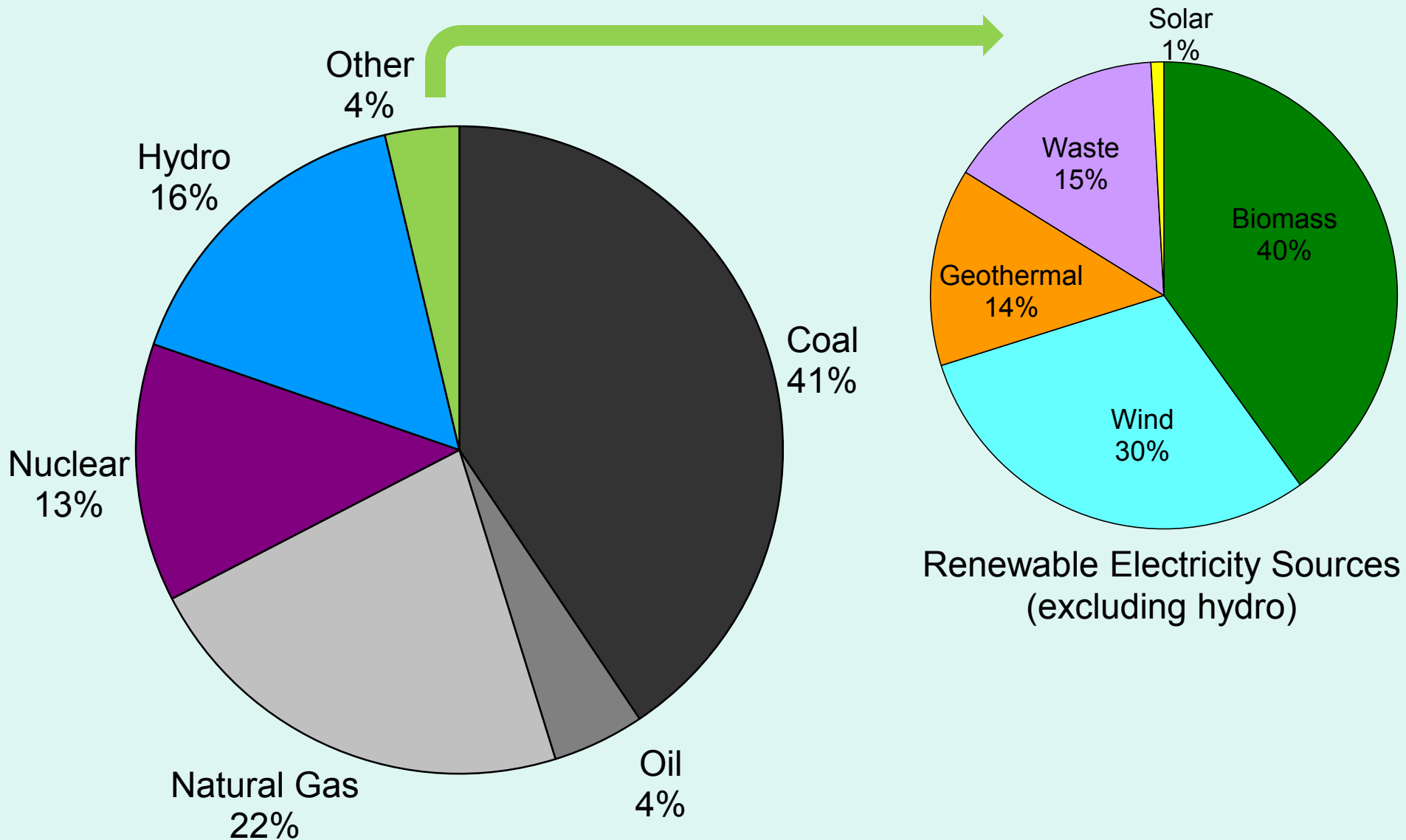
---



81% Fossil Fuels  
(Coal, Oil, Natural Gas)

# World Electricity Sources

---



# Montana Electricity Sources

---



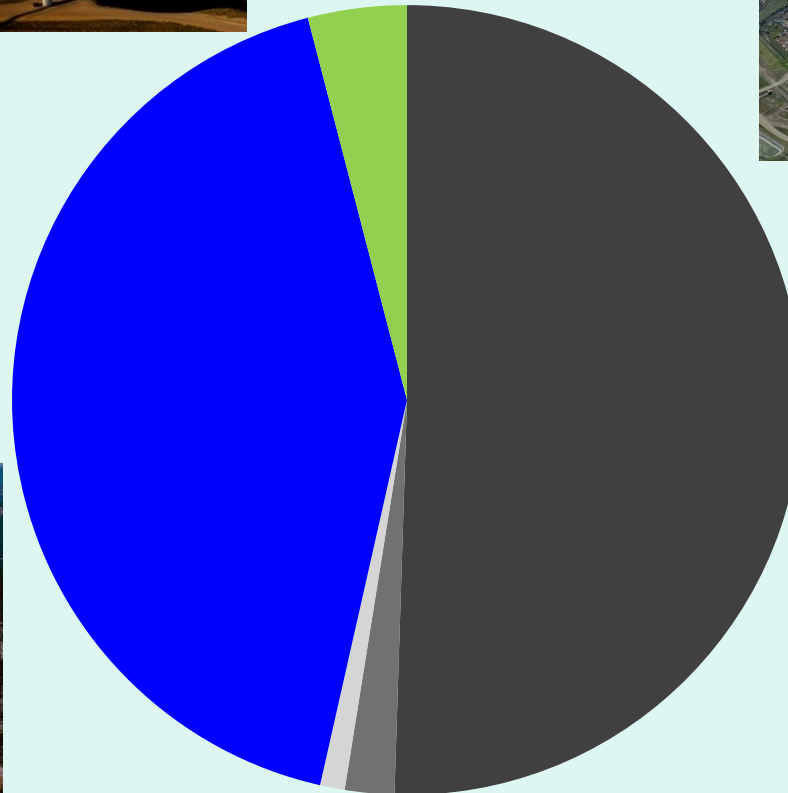
Wind  
4%



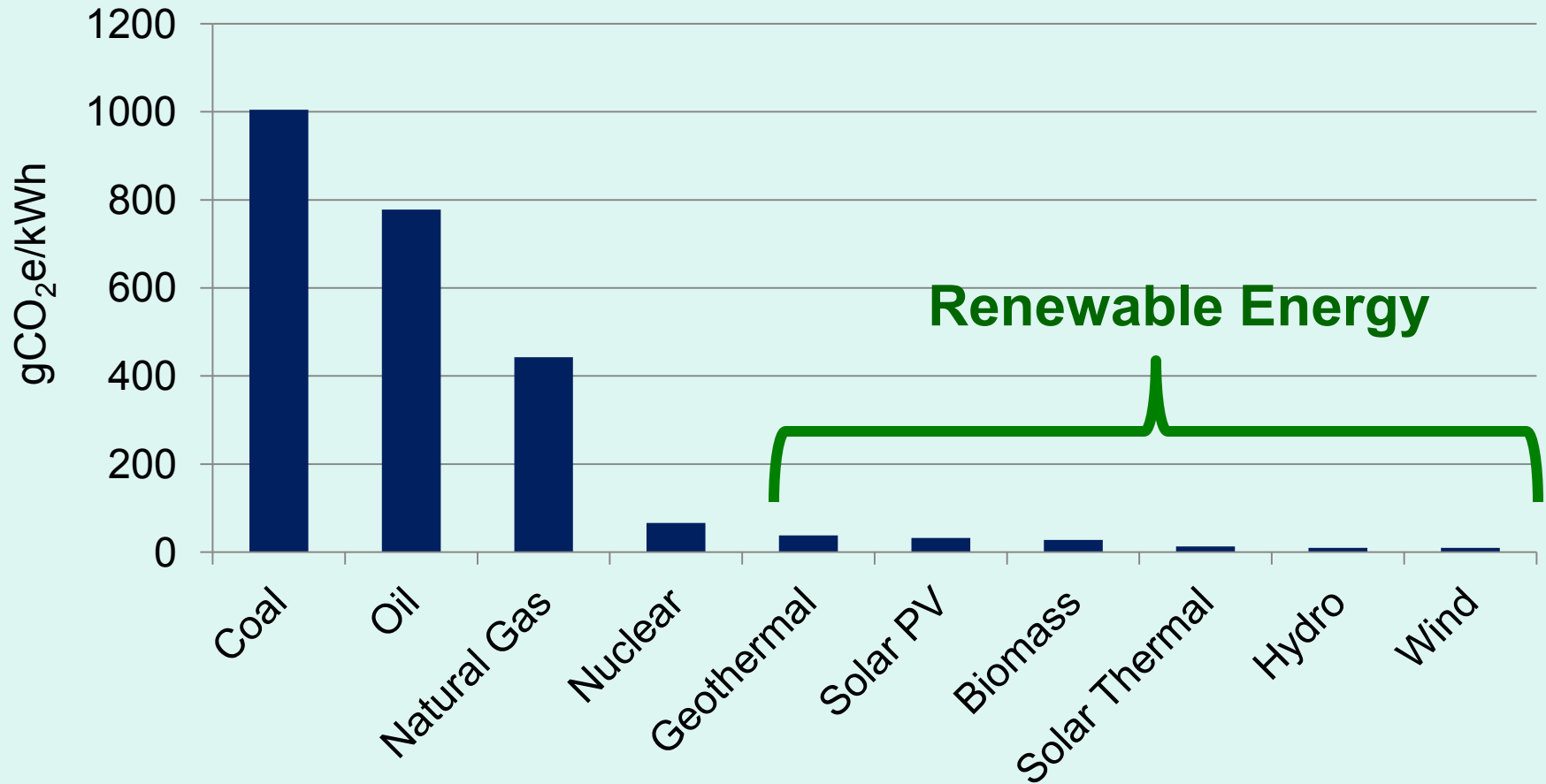
Coal  
51%

Hydro  
42%

Natural Gas 1%  
Petroleum 2%



# Lifecycle Greenhouse Gas Emissions for Electricity Generation





# Other Benefits of Renewable Energy

---

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



# Agenda

---

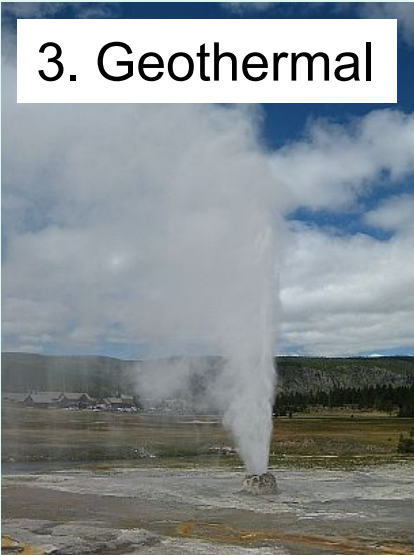
## 1. Wind



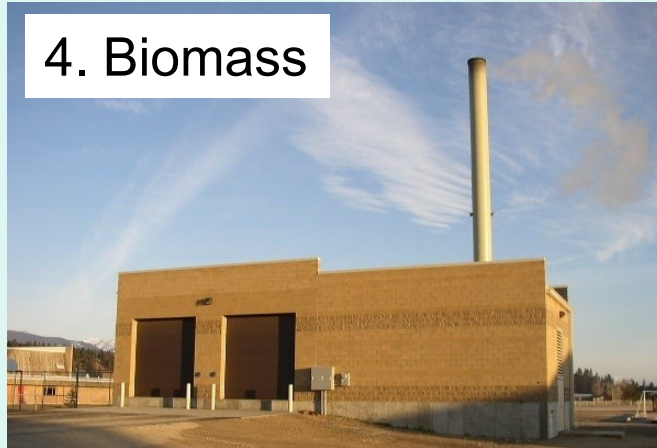
## 2. Solar



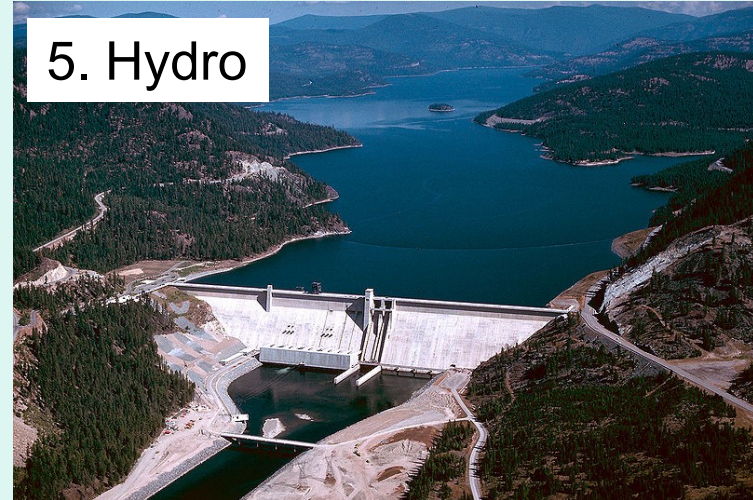
## 3. Geothermal



## 4. Biomass

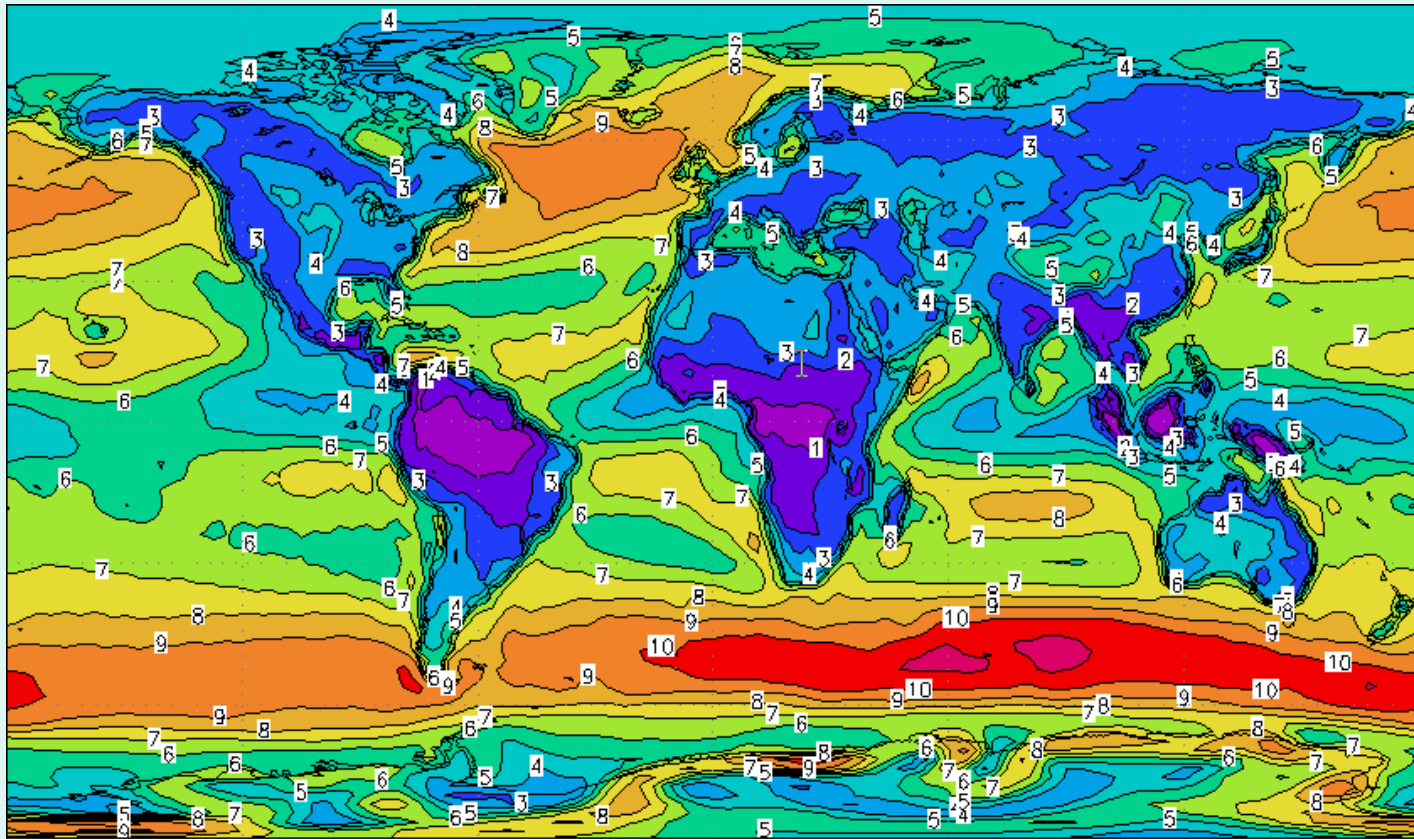


## 5. Hydro





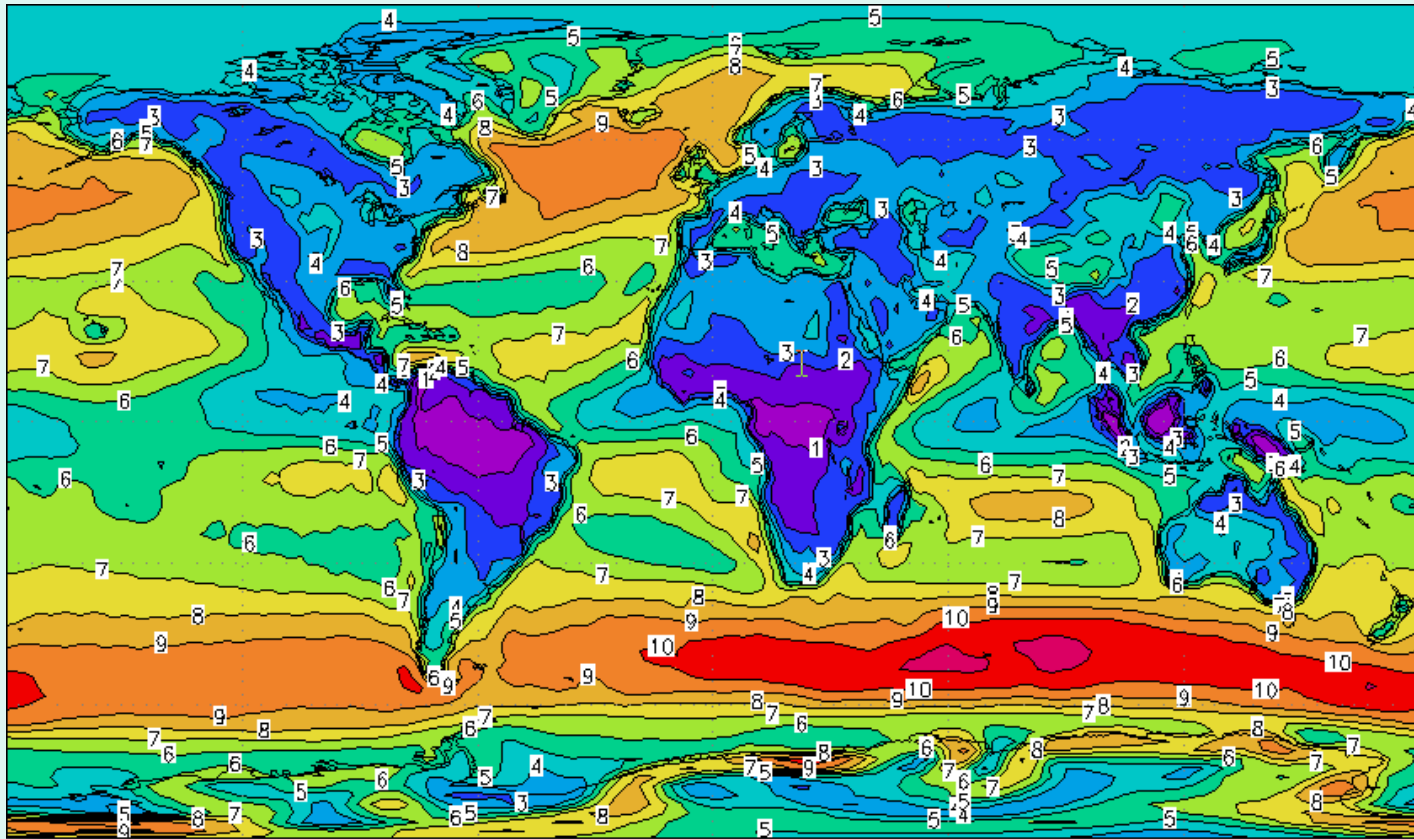
# Wind Energy: The Resource



Map: windatlas.dk

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

# Wind Energy: The Resource



Map: windatlas.dk

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

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

Jacobson and Delucchi, 2009

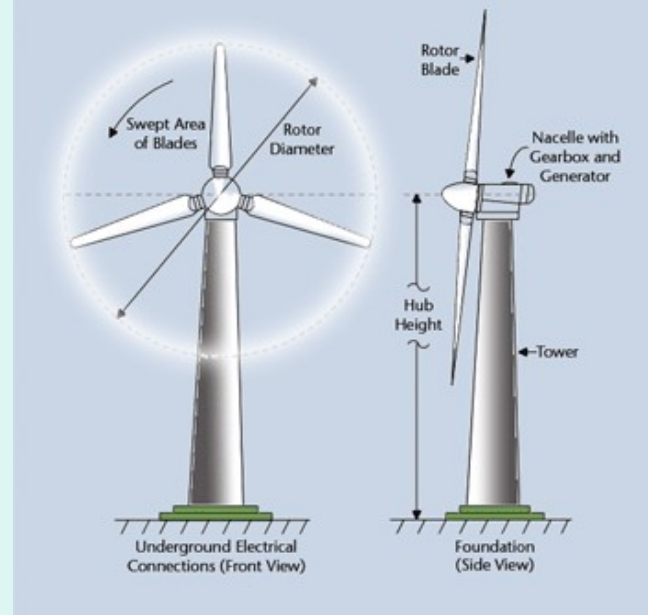
# Wind Turbine Technologies



Small Wind  
10 kW



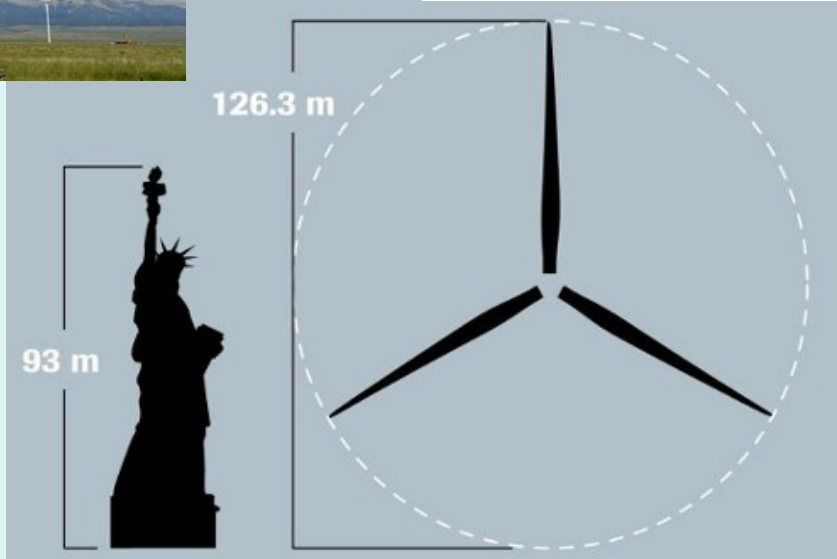
Big Wind  
1.5 MW



Really Big Wind  
7 MW



Vertical Axis



93 m

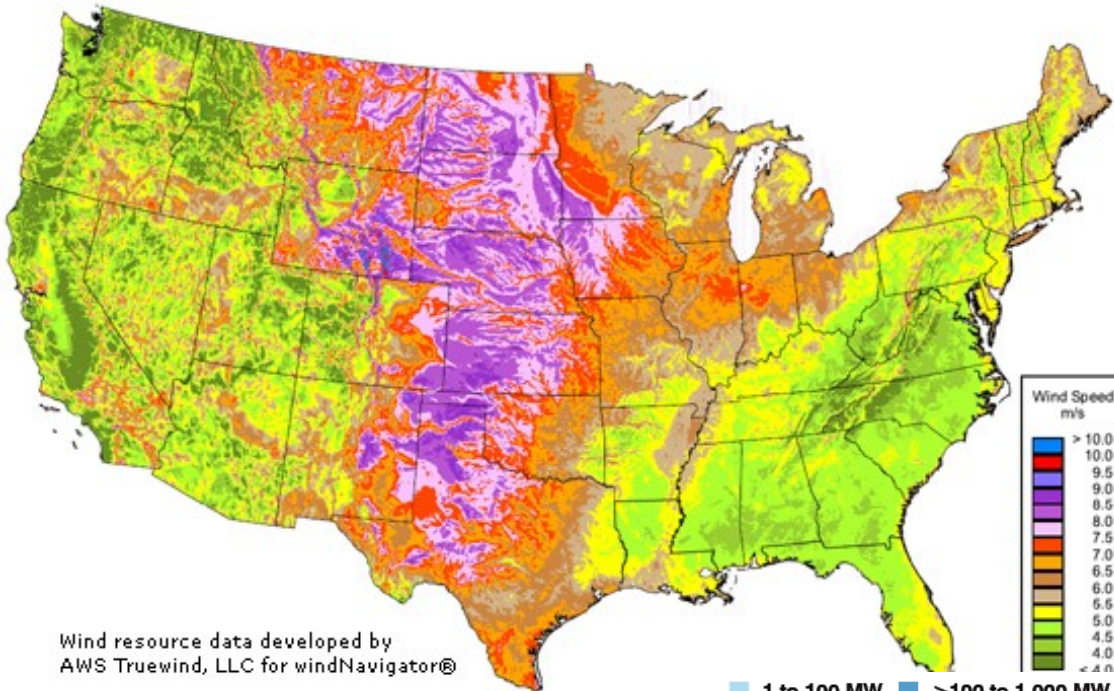
126.3 m



# Improving Technology



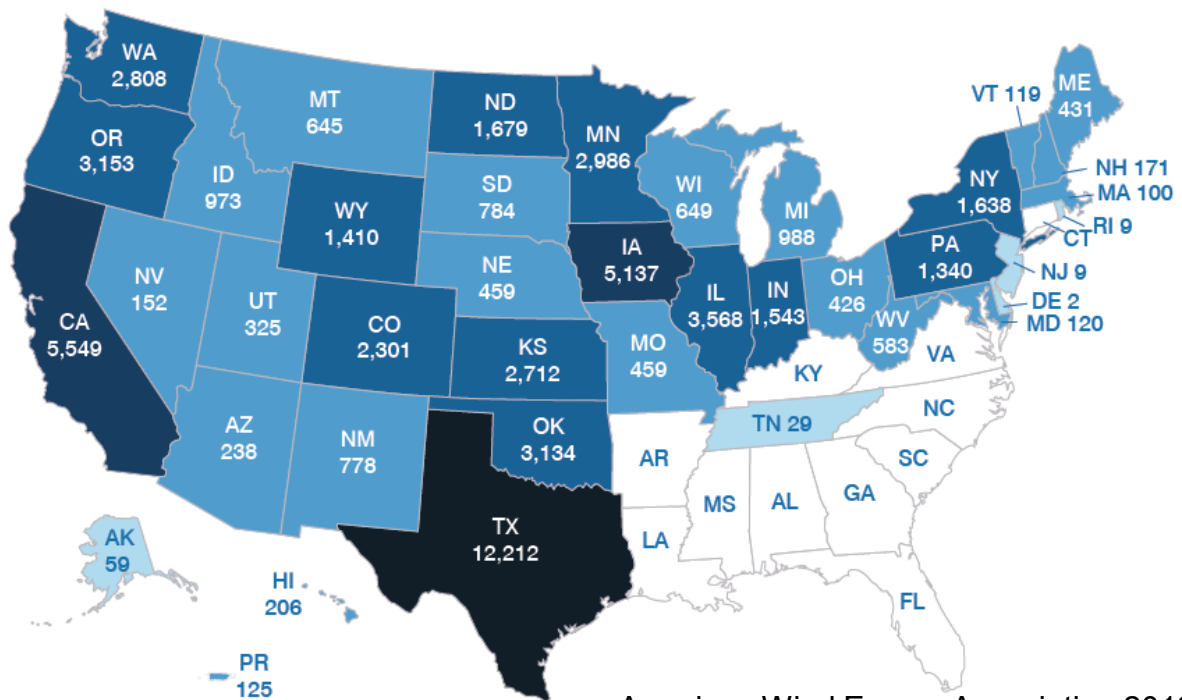




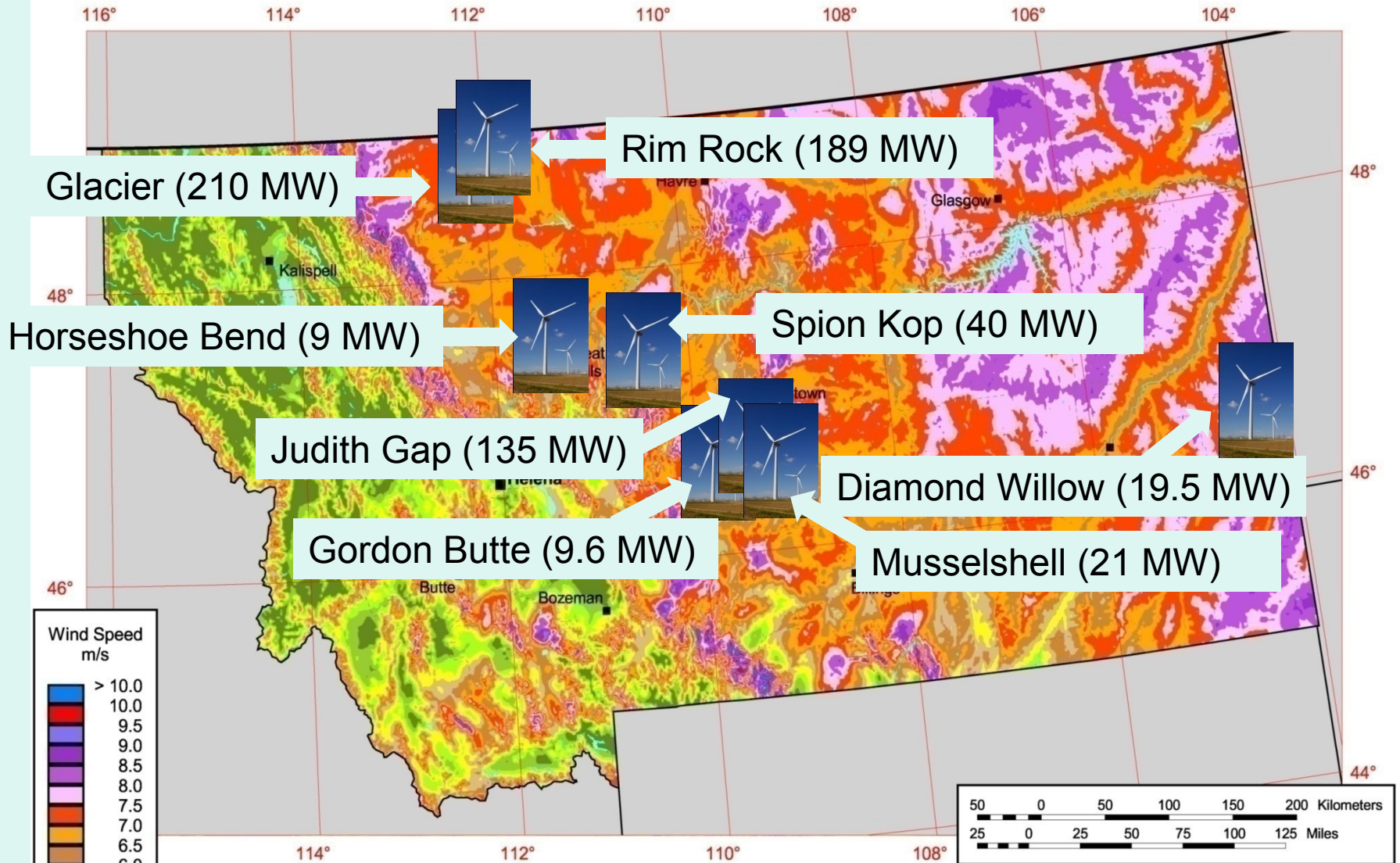
Montana wind resource ranks among the top 5 in the nation...

1 to 100 MW    >100 to 1,000 MW    >1,000 MW to 5,000 MW    >5,000 MW to 10,000 MW    > 10,000 MW

...but we rank 21<sup>st</sup> in terms of installed wind energy capacity



# Montana Wind Farms



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

# Economic Impacts of Judith Gap, a Montana Wind Farm

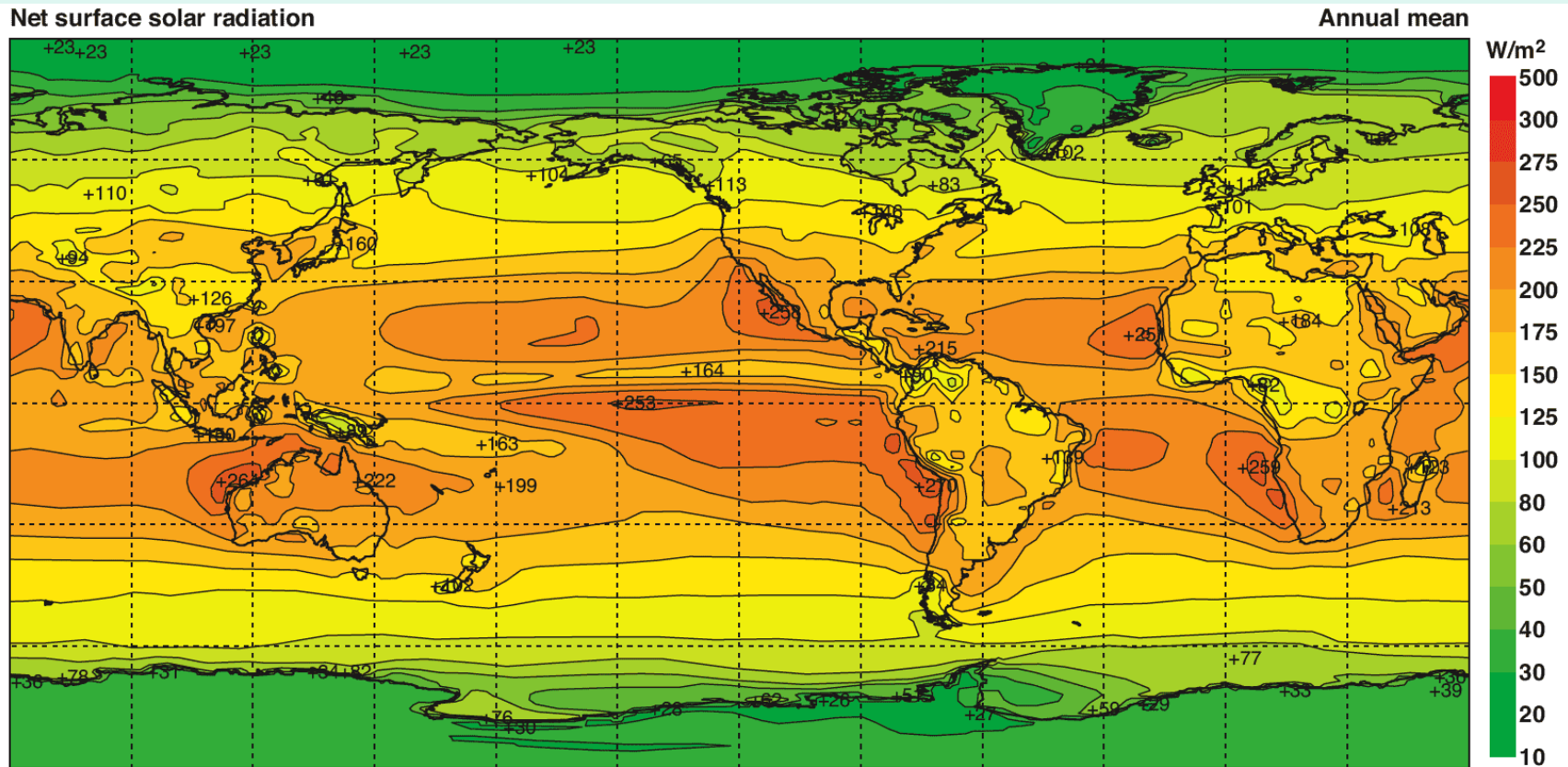
---

- 200 construction jobs
- 12 permanent, full-time employees
- \$28 million in economic benefits over 5 years
  - \$5 million Wheatland County tax revenue
  - \$3 million wages
  - \$2.2 million royalties for landowners
  - \$18 million construction
- Provides 7-8% of NorthWestern Energy's power at lower cost than other NorthWestern Energy sources





# Solar Energy: The Resource

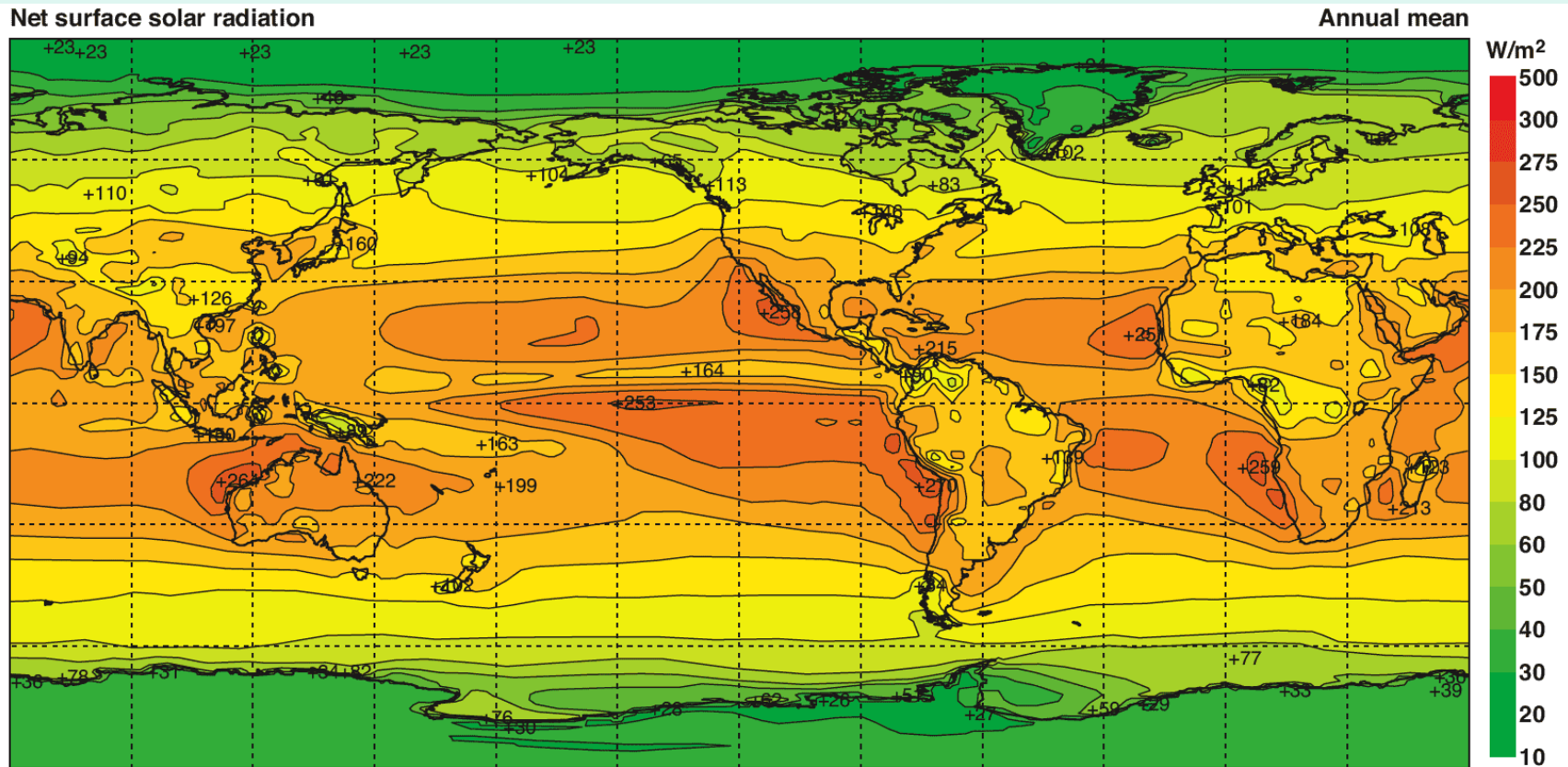


Map: ERA-40 Atlas

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



# Solar Energy: The Resource



Map: ERA-40 Atlas

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

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

Jacobson and Delucchi, 2009

# Solar Photovoltaic Energy



There are more than 1,000  
grid-tied solar PV  
installations in Montana





# Solar Photovoltaic (PV) Technologies

---

## Monocrystalline Silicon



Photo: Lincoln Electric Co-op /  
Thirsty Lake Solar

*“Photovoltaic” = Light-Electricity*

## Polycrystalline Silicon



Photo: Sage Mountain Center

## Thin Film

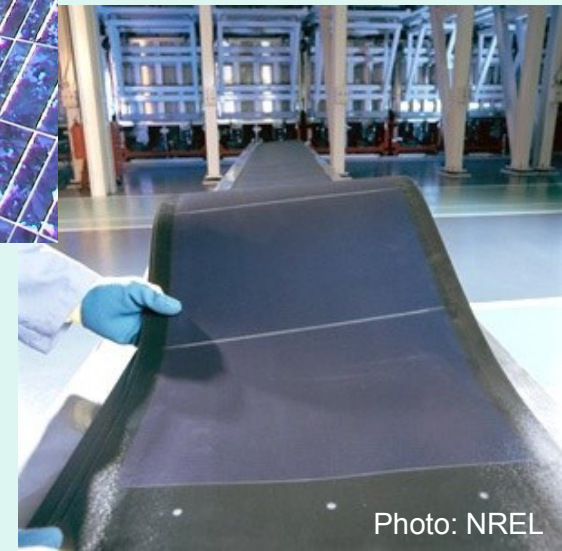
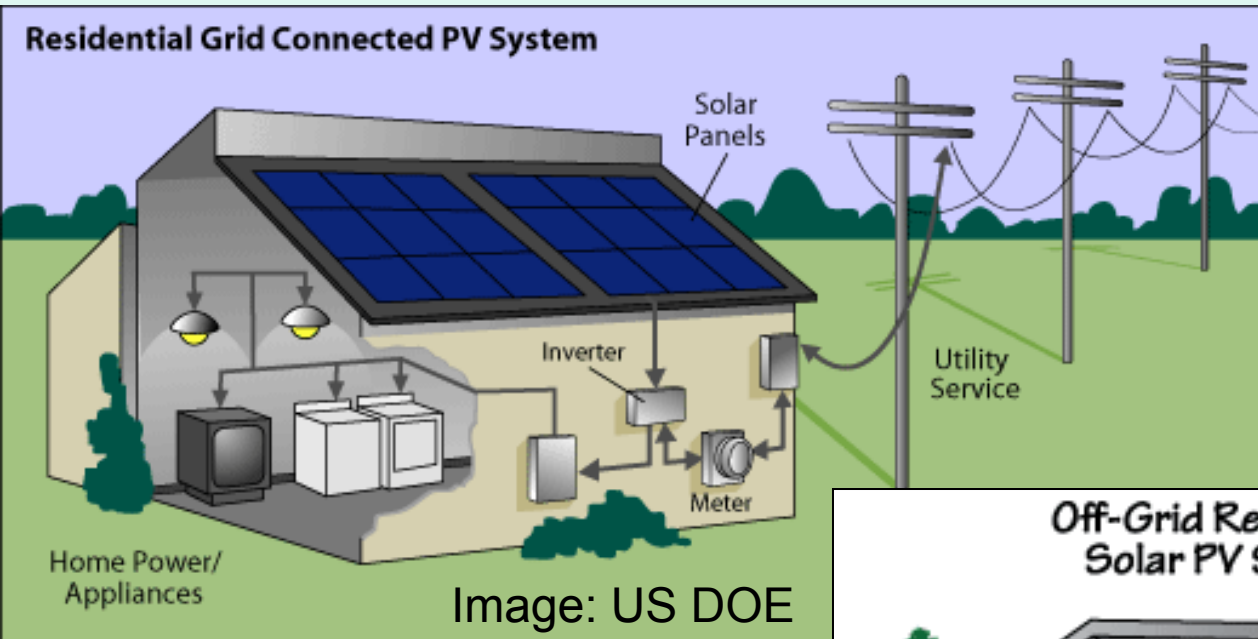


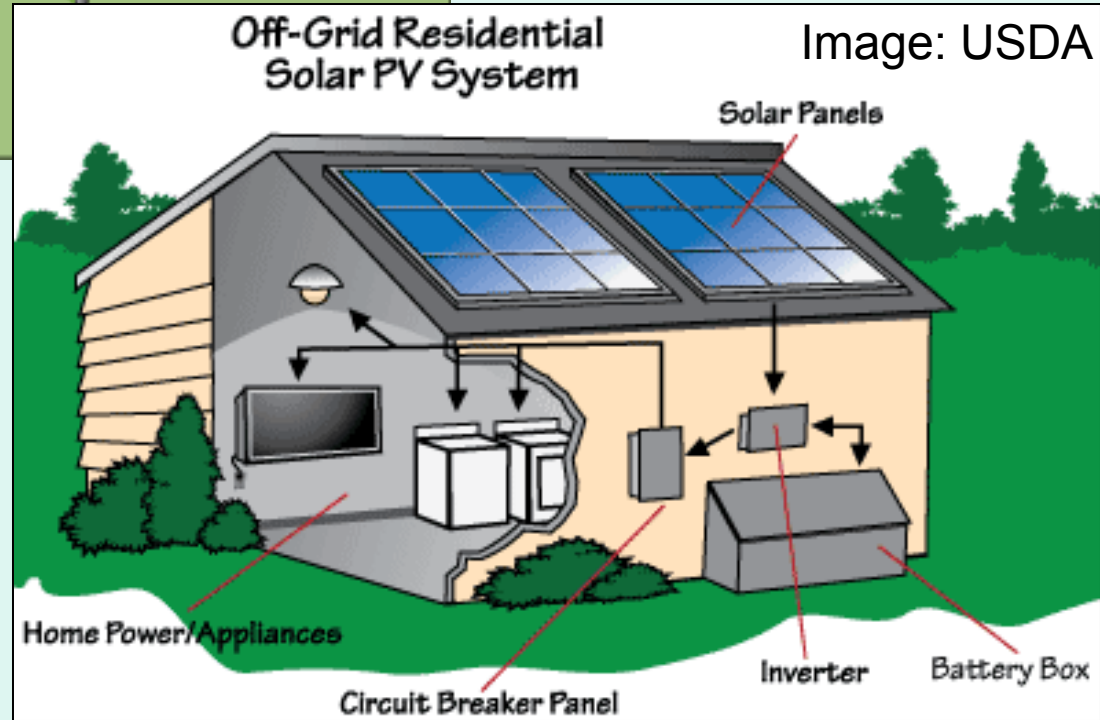
Photo: NREL

Efficiency

# Types of PV Systems



**Off-Grid**



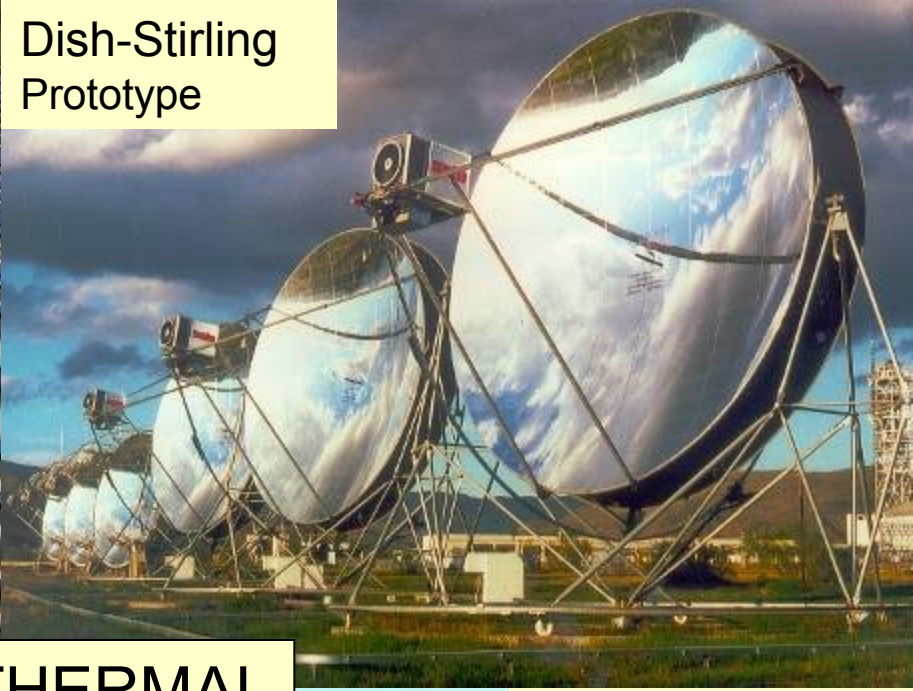
**Grid-Tied**



Solar Power Towers  
Spain



Dish-Stirling  
Prototype



Fresnel Reflectors  
Prototype



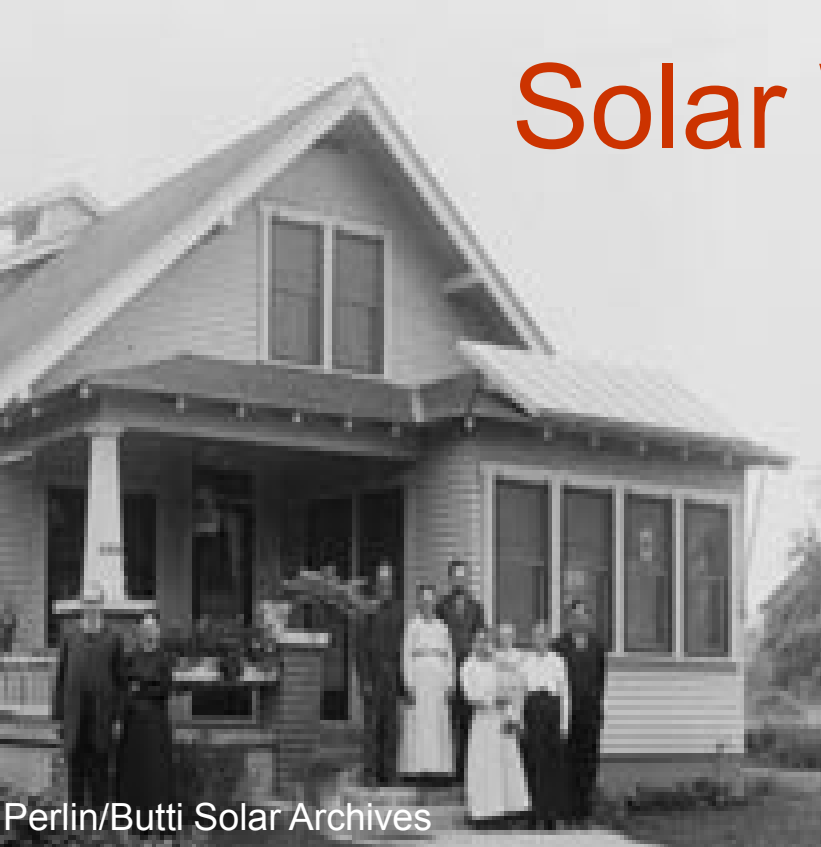
**SOLAR THERMAL**

Parabolic Trough  
SEGS, California





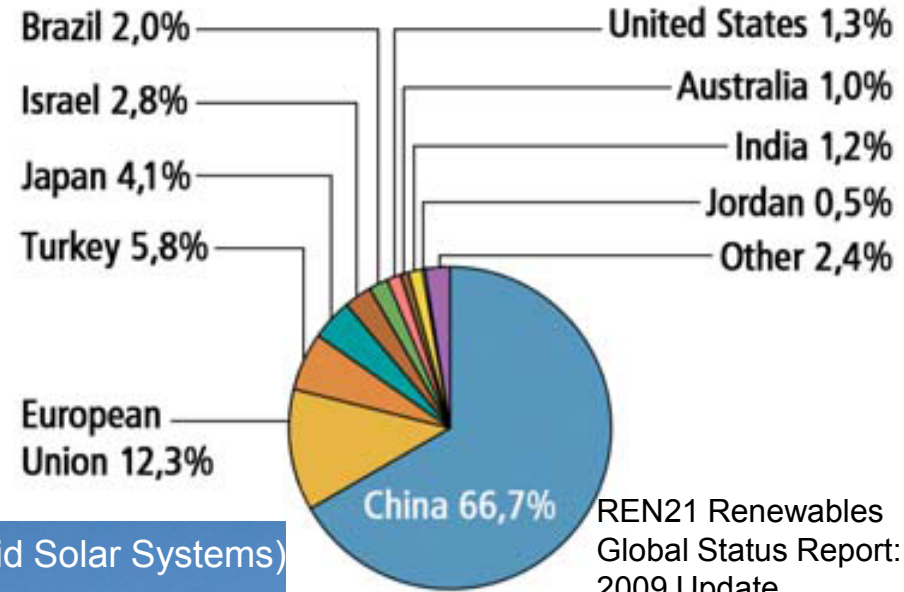
# Solar Water Heating



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

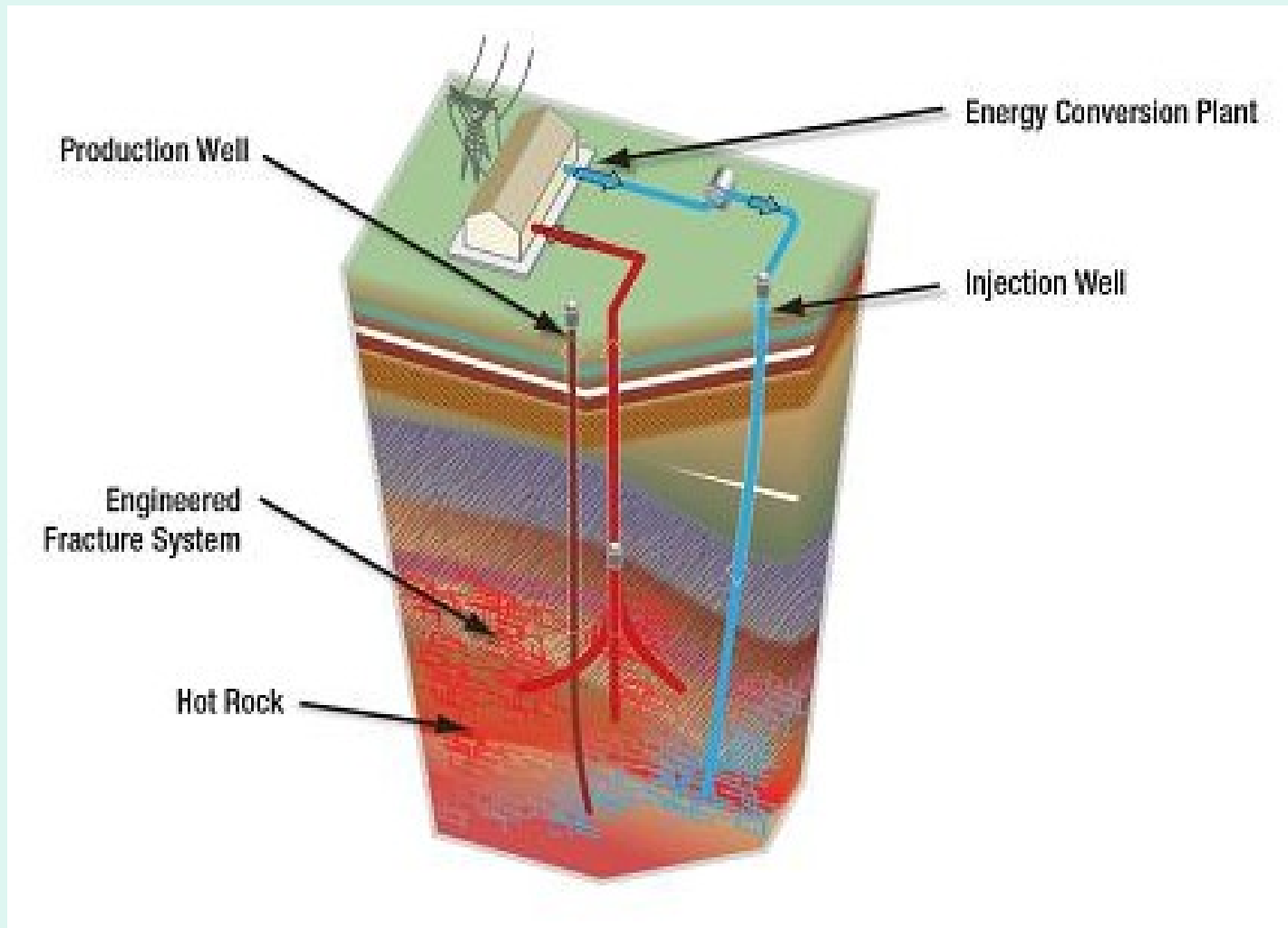
**Power Plants:** Dry steam, Flash steam, Binary cycle

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





# Geothermal (Ground Source) Heat Pumps

## Closed Loop Systems

Horizontal

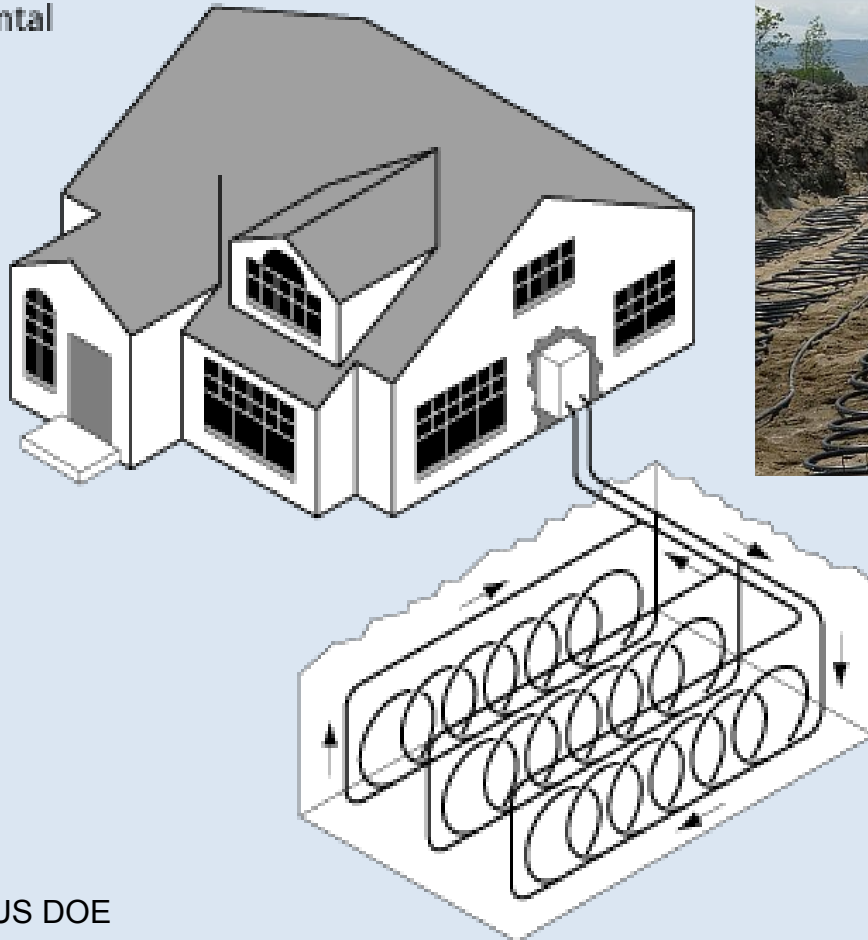


Photo: Intermountain Heating, Helena

# Biomass Energy

## Uses:

- Heating
- Electricity Generation
- Transportation Fuel

## Biomass

## Feedstocks:

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



**Biomass boiler at Darby Schools**



**Flathead County Landfill Gas Project**



# Hydropower

*Big dams provide 16% of worldwide electricity; 32% in Montana*



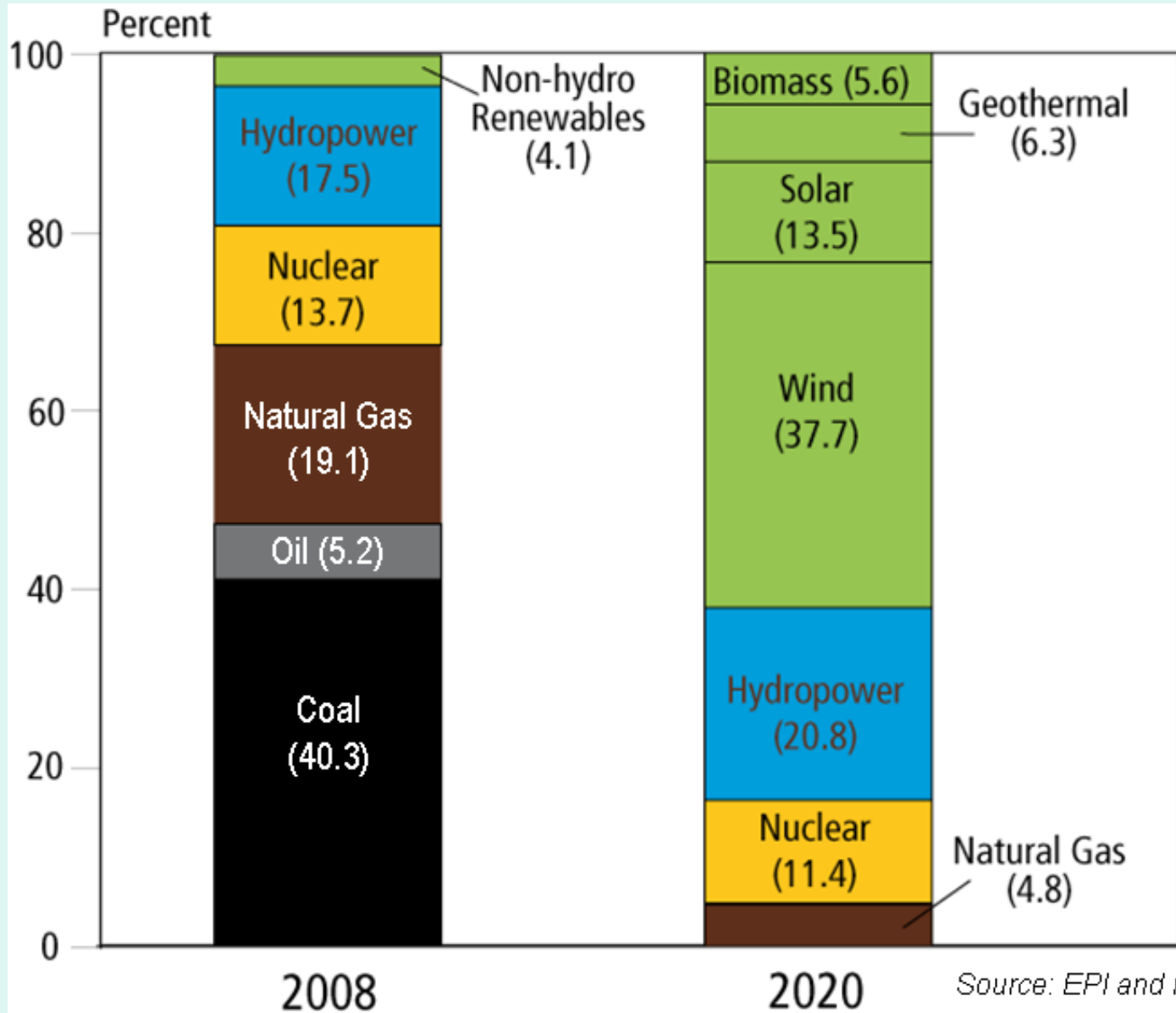
Large Hydro (Libby Dam, Montana)



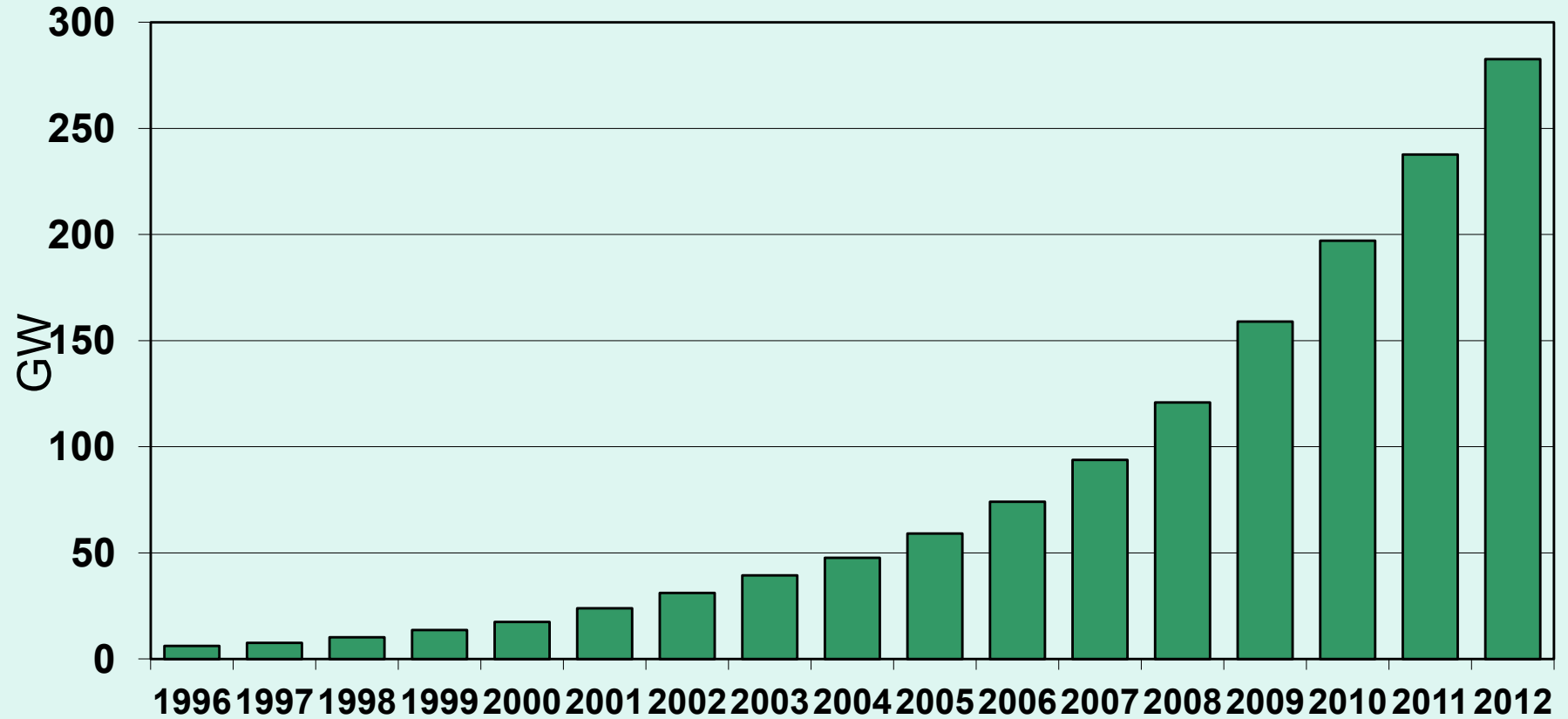
Micro-Hydro (Photo Credit: Solar Plexus)



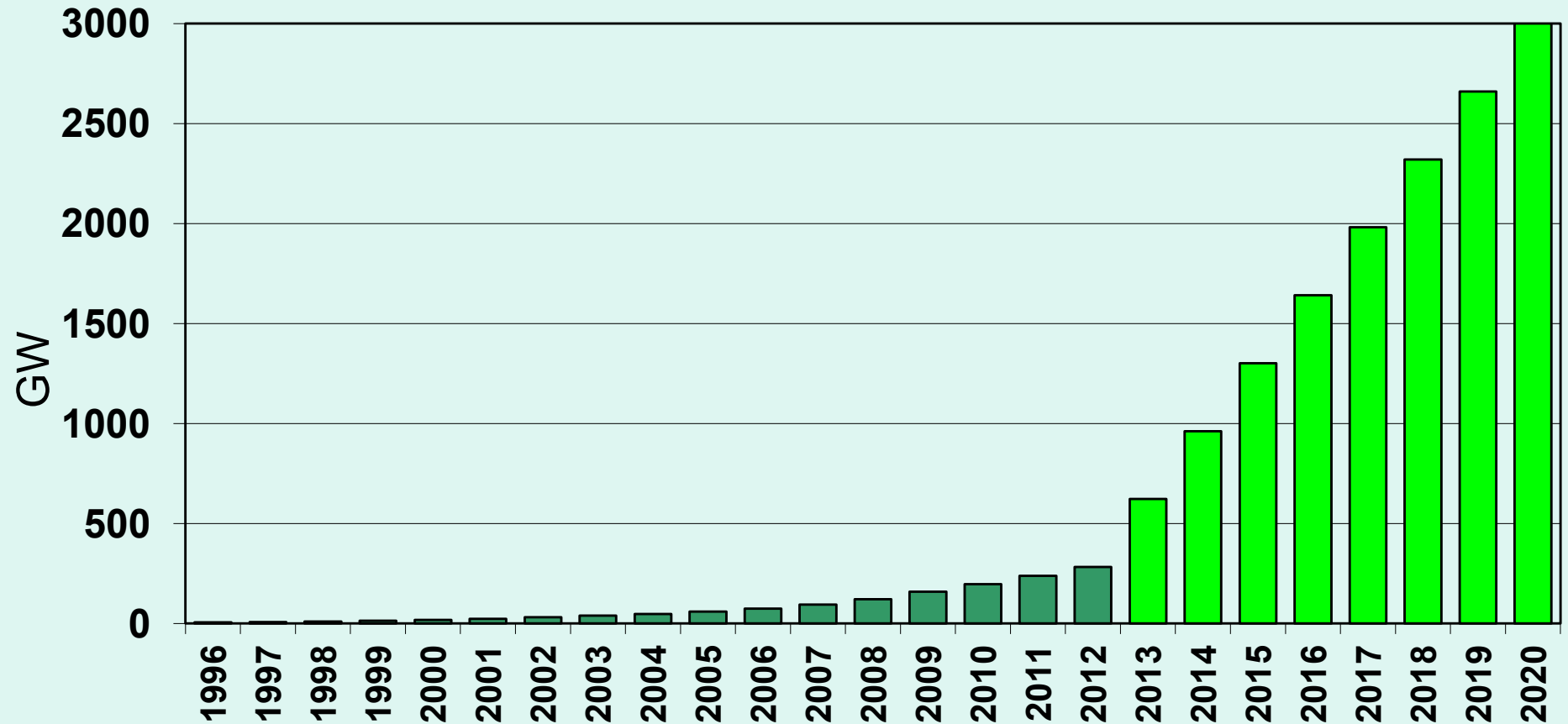
# Lester Brown: Plan B



# Global Wind Capacity

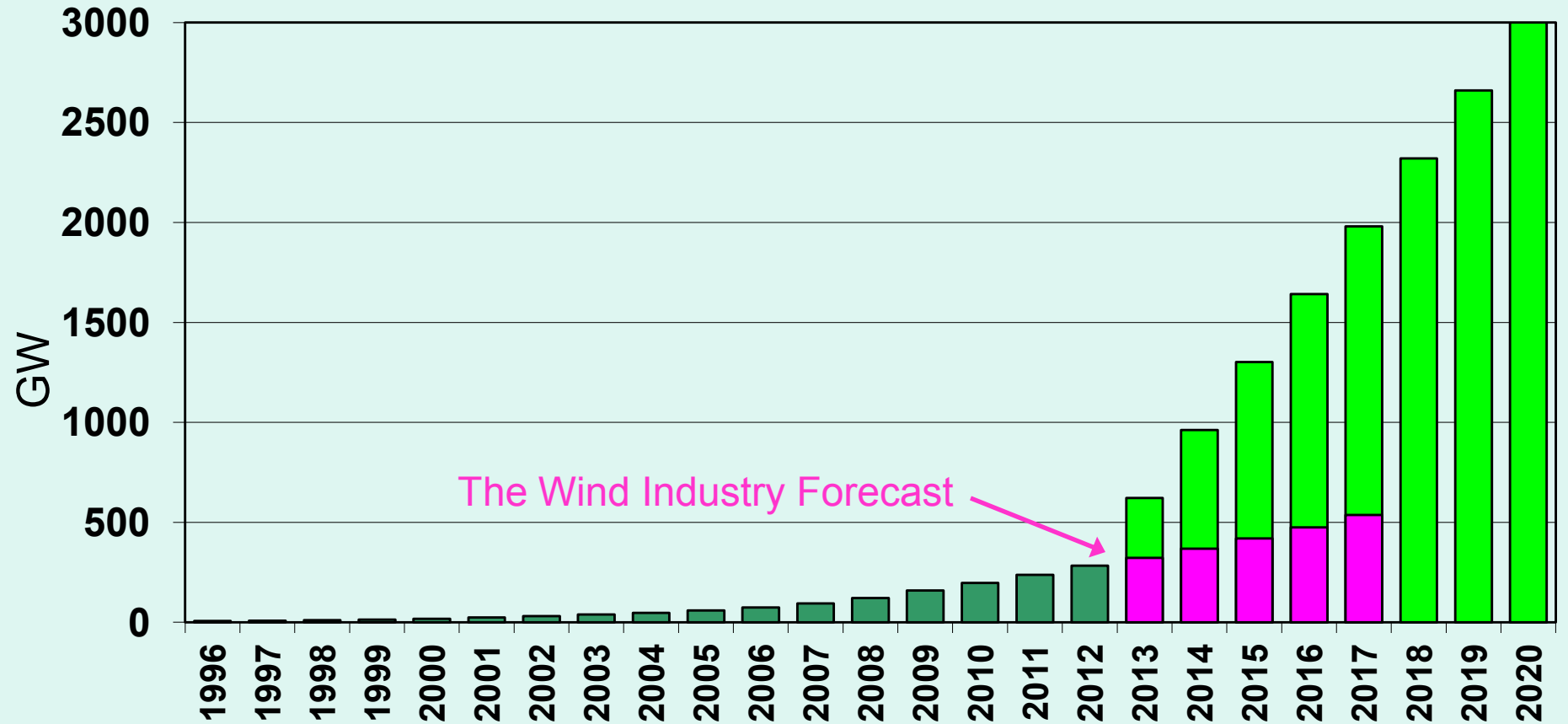


# The Plan B Goal: 3,000 GW Wind in 2020

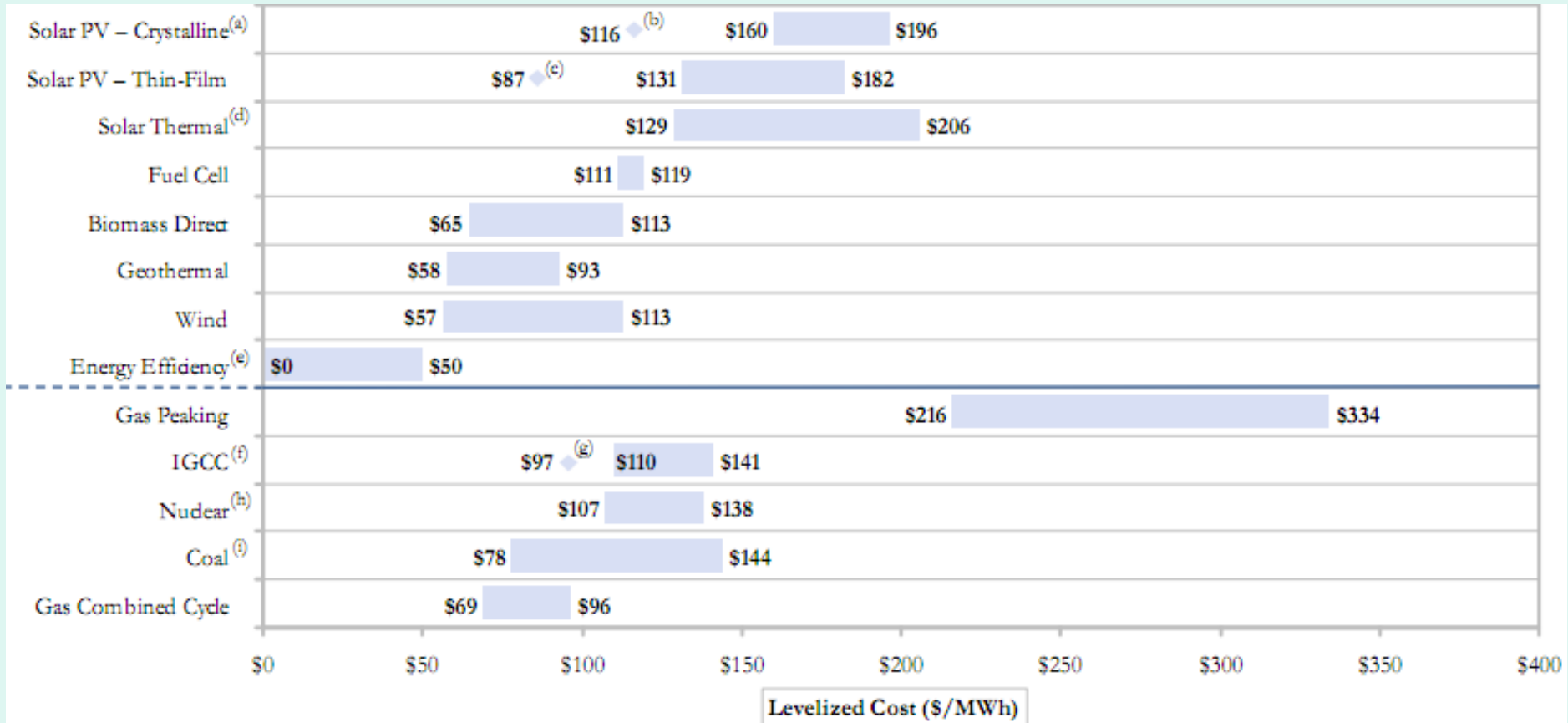




# The Plan B Goal: 3,000 GW Wind in 2020



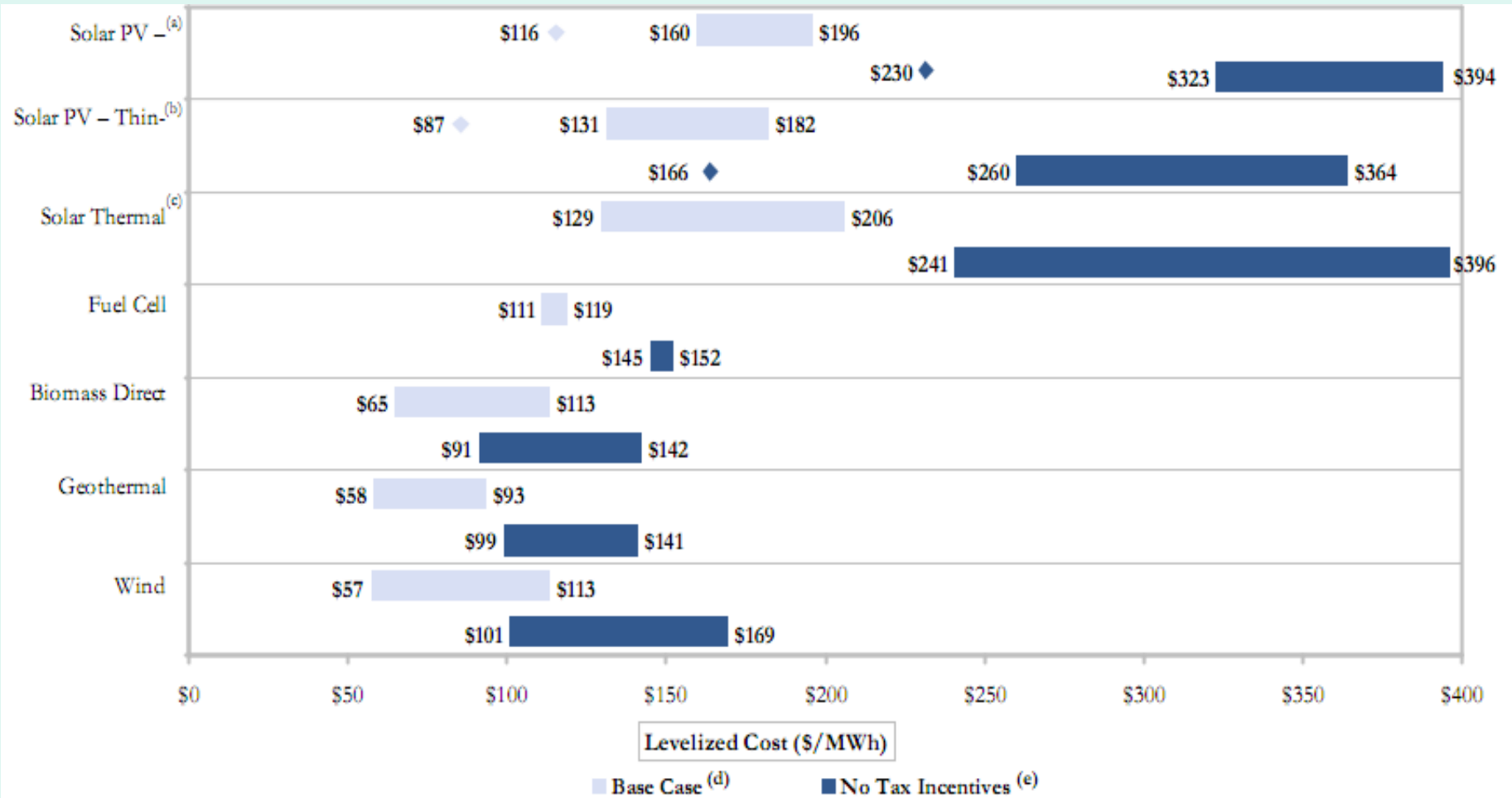
# Renewable Electricity Costs



Source: Lazard's Levelized Cost of Energy Analysis 2009

***With current federal tax incentives...***

# Renewable Electricity Costs

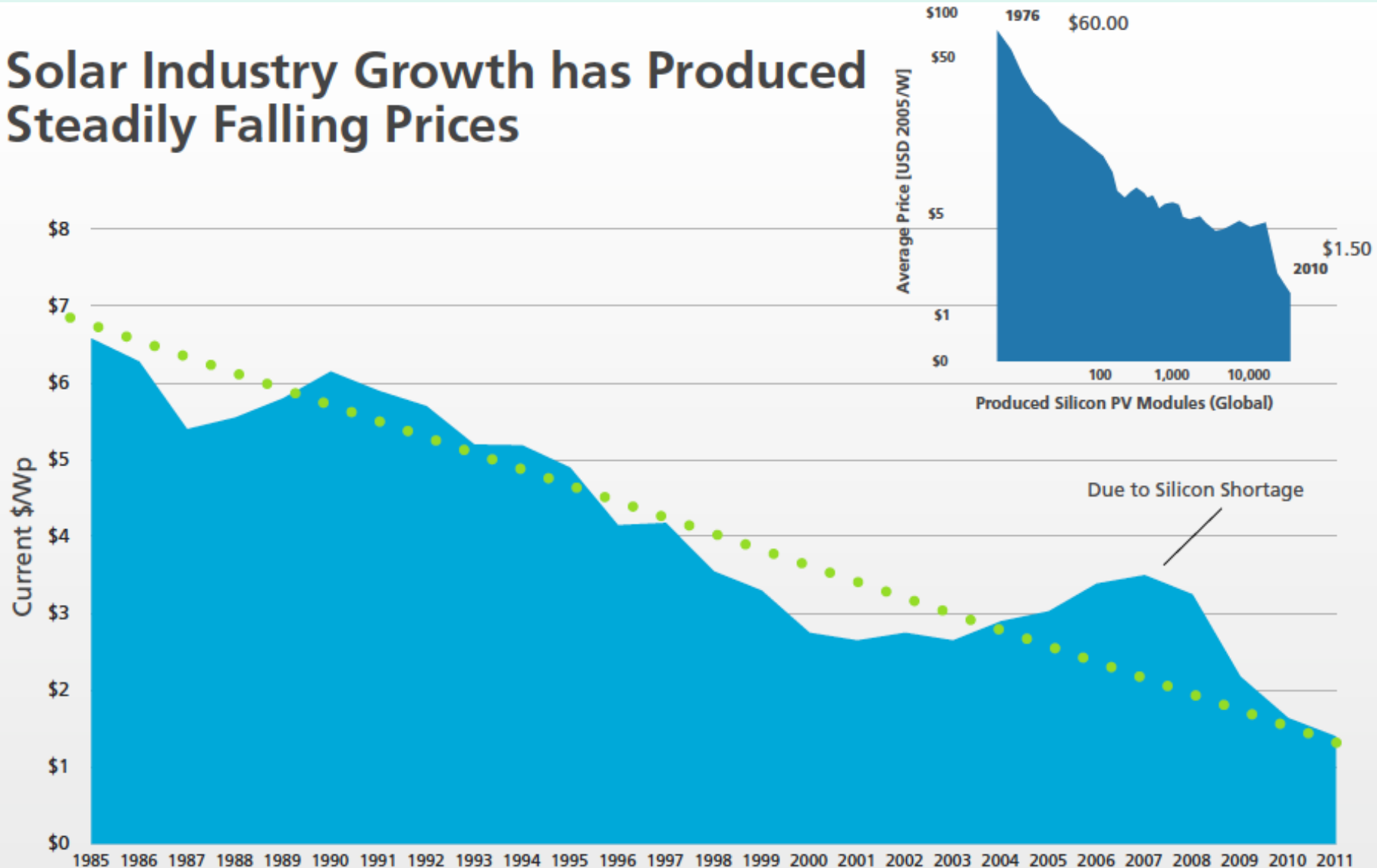


Source: Lazard's Levelized Cost of Energy Analysis 2009

***...and without tax incentives***



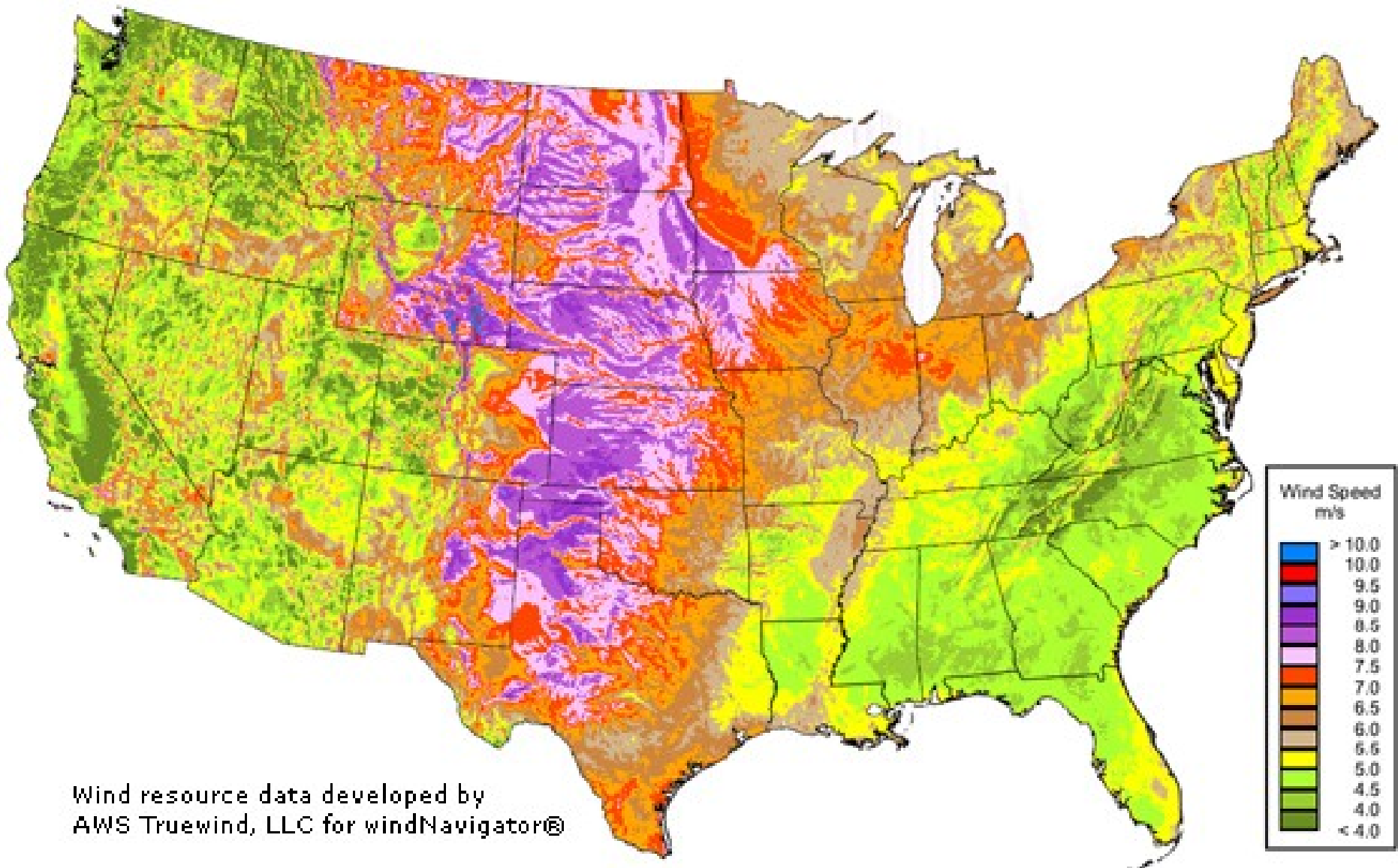
# Solar Industry Growth has Produced Steadily Falling Prices



Module Pricing Trends 1985-2011

Sources: 1976 -1985 data from IPCC, Final Plenary, Special Report Renewable Energy Sources (SRREN), May 2011; 1985-2010 data from Paula Mints, Principal Analyst, Solar Services Program, Navigant; 2011 numbers based on current market data

# US Wind Resource

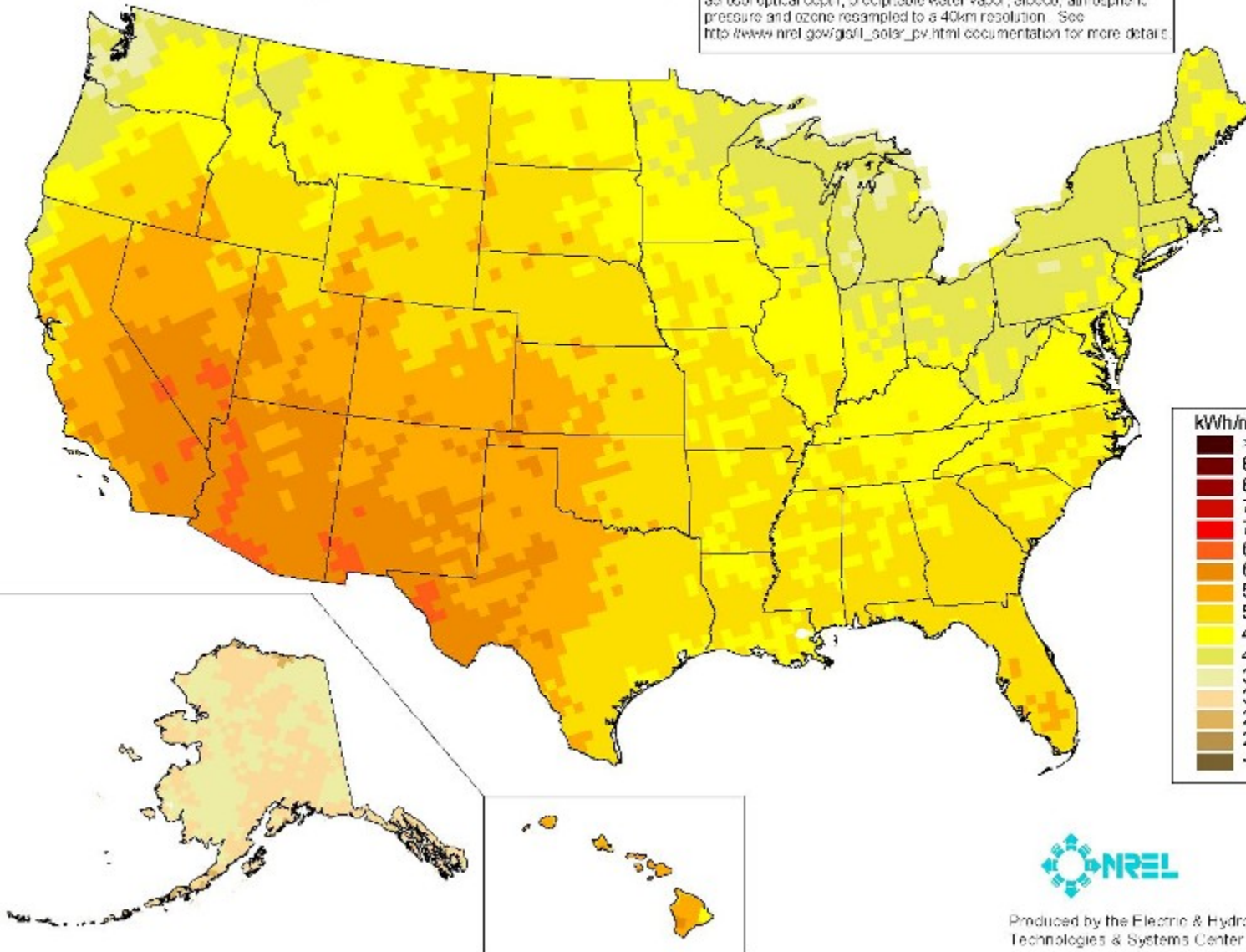


# US Solar Resource

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

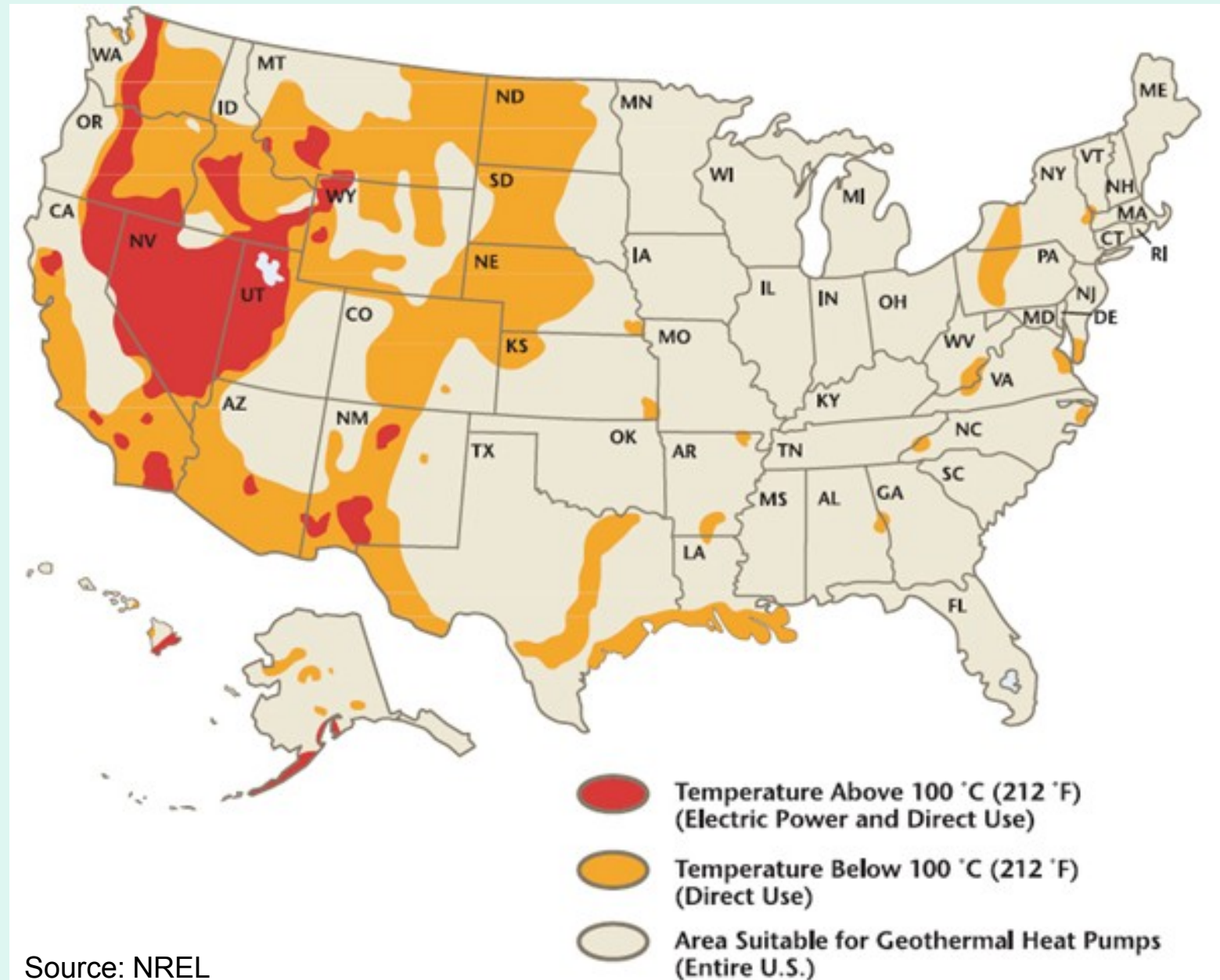
Annual

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](http://www.nrel.gov/gis/solar_pv.html) documentation for more details.



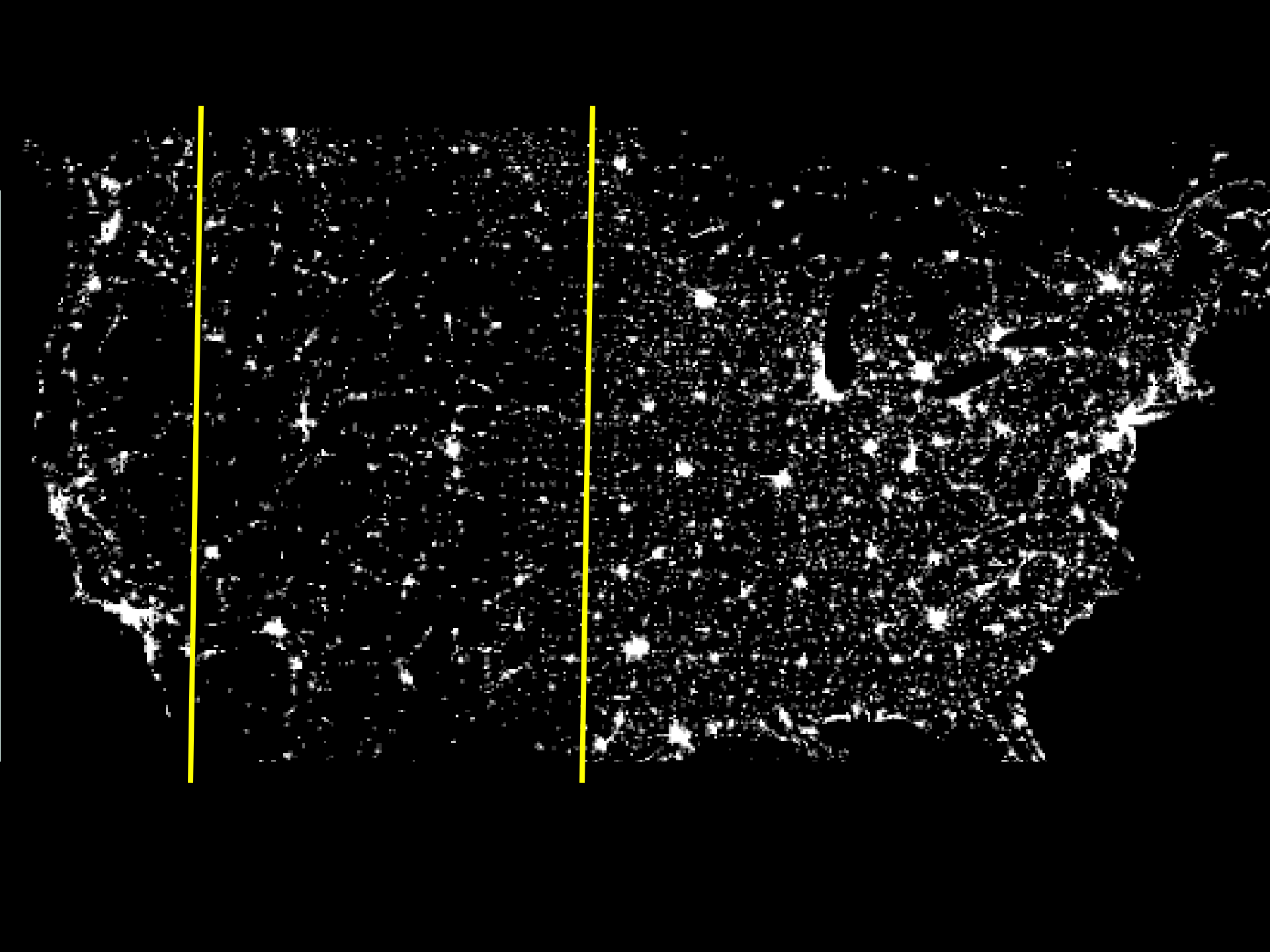


# US Geothermal Resource



Source: NREL





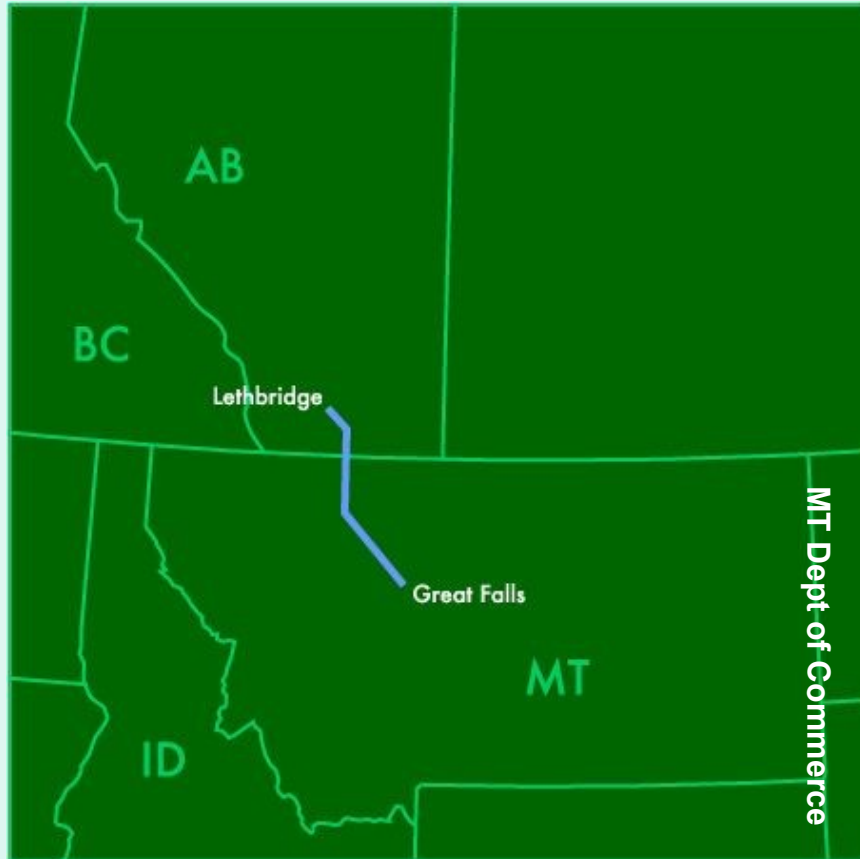
# The Challenge: Transmission



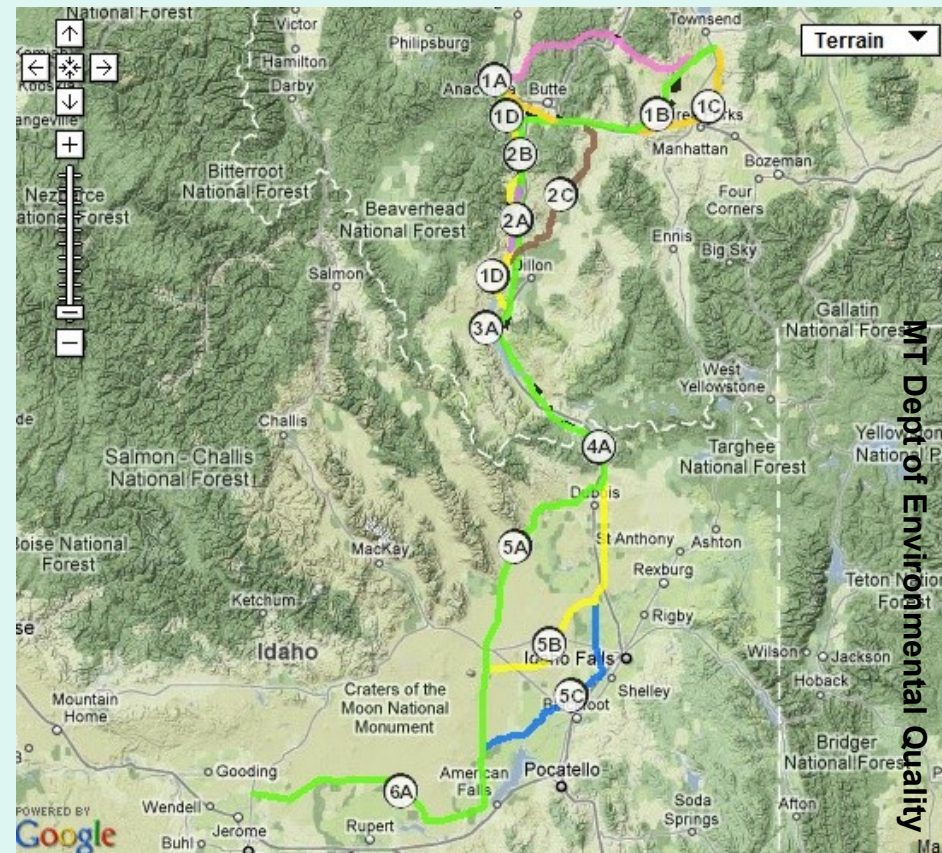
- High cost
- Environmental and regulatory challenges
- Long construction time



# Montana Transmission Projects



Montana-Alberta Tie Line (MATL)



Mountain States Transmission Intertie (MSTI)

# Battle Over Mont. Transmission Line Stymies Wind Development

By PHIL TAYLOR of Greenwire  
Published: August 24, 2011

Second in a two-part series on Montana transmission. [Click here for the first story.](#)

## More News From Greenwire

- King Corn Takes Root in Hawaii
- Creek Restoration Keys Cincinnati's Battle Against Urban Blight, Stormwater
- EPA Retreats Again From Planned Regulation of Construction Runoff
- Protest Makes Canada-To-U.S. Pipeline Project Newest Front in Climate Clash
- Presidential Candidate Perry Championed Pesticides, Torpedoed Regs as Texas Ag Chief

BOULDER, Mont. -- Marie Garrison says her family has done its part to support electricity development in rural Montana.

Garrison, a mother of two who grazes about 350 pair of cattle on her ranch south of Butte, points to two transmission lines behind her home that carry electricity along Interstate 15 to residents in nearby Dillon, Mont.

A local utility paid her husband's grandfather \$1 in the 1950s for the right to build the lines on his property, she said. The 60-foot-tall wooden poles make a subtle mark

# High Country News

For people who care about the West

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Advanced Search

# Montana transmission lines draw opposition from all sides



# State supreme court reverses ruling on MSTI consultation

BUTTE — The Montana Supreme Court has reversed a lower court's ruling that the state did not adequately consult with Jefferson County while reviewing a proposed major power transmission project.

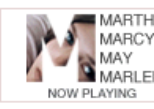
In its decision, the court reversed district Judge Loren Tucker's September 20 ruling that the Montana Department of Environmental Quality, or DEQ, had not violated its legal duty to consult with Jefferson County.

Prior to the lawsuit with Jefferson County, the DEQ had been preparing to release an impact statement for NorthWestern Energy's proposed 500-kV Mountain State Transmission Initiative, or MSTI.

Judge Tucker ruled in favor of Jefferson County's claim that it hadn't been adequately consulted while developing the document and further enjoined the state from releasing its impact statement.

SIGN IN TO EMAIL

PRINT



# Plans advance for embattled Montana power line

MATT GOURAS, Associated Press  
Updated 12:45 p.m., Tuesday, August 16, 2011

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Larger | Smaller   Email This

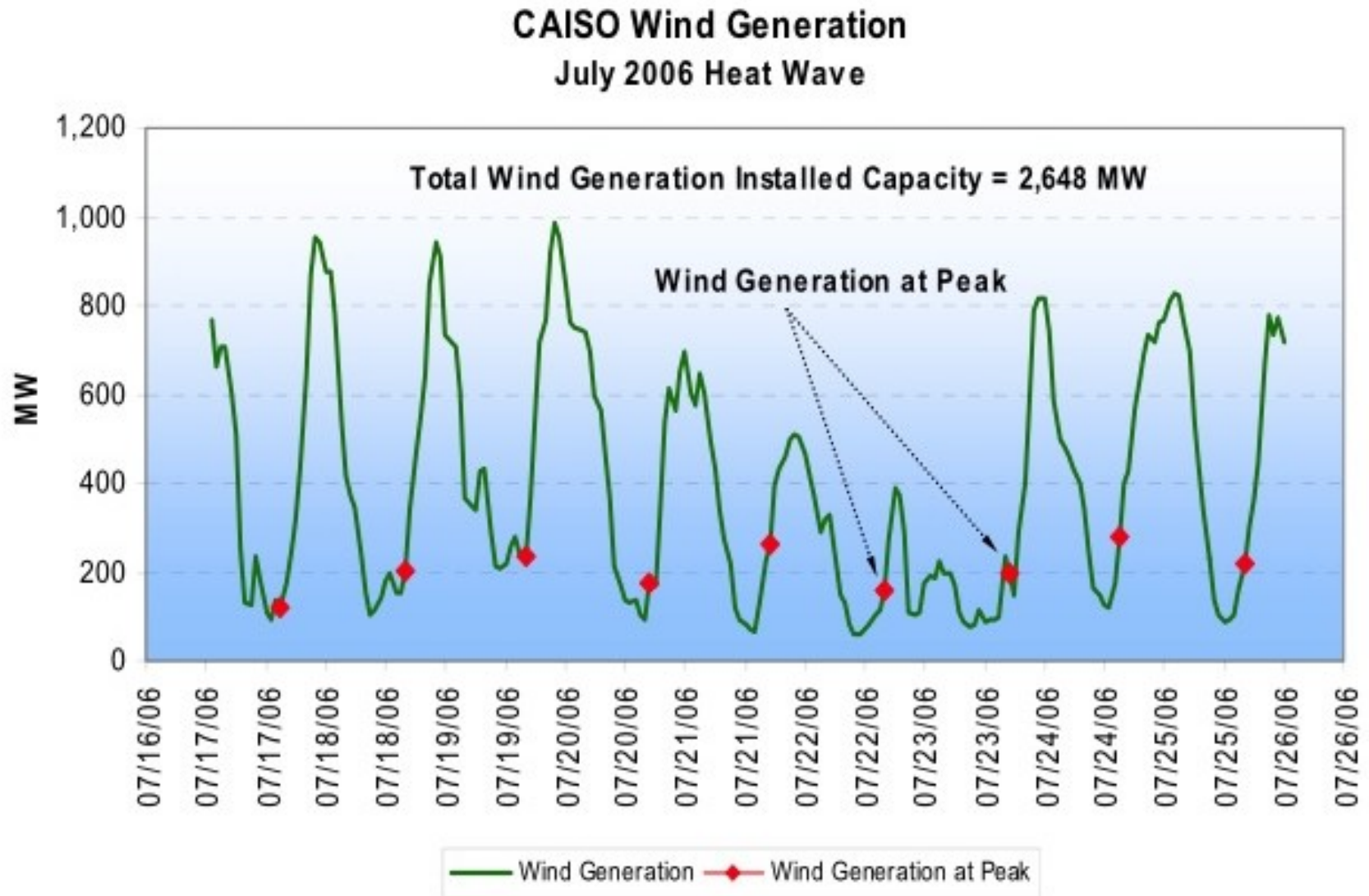
Printable Version   Font

HELENA, Mont. (AP) — A Canadian energy company said Tuesday that it is buying an embattled power transmission line project that has seen opposition from landowner disputes. Alberta-based Enbridge announced the purchase the same day the company announced a significant settlement with a local group opposing the project.

Enbridge's plans to purchase Tonbridge Power Inc. — whose main business involves operating the Montana-Alberta Tie Line power transmission project — in a deal worth \$70 million requires shareholder approval.

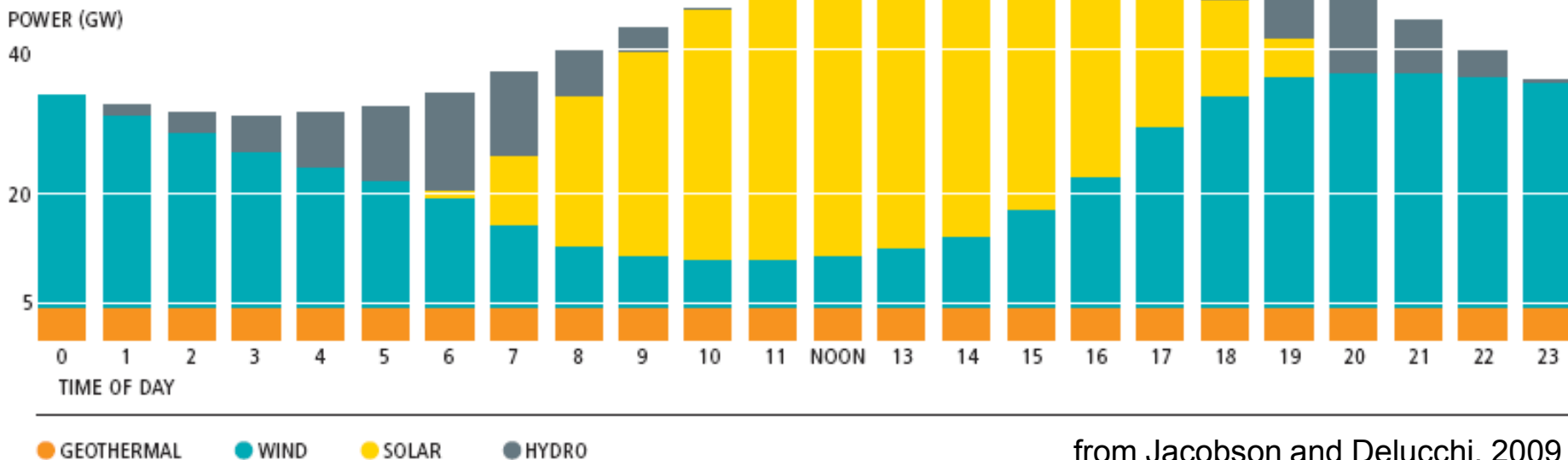


# The Challenge: Intermittency



# Accommodating Intermittency

- Complementary Resources
- Wind and Solar Forecasting
- Energy Storage



from Jacobson and Delucchi, 2009



# The Challenge: Environmental Impacts



Dual land use: Rio Vista Wind Farm, California

# BloombergBusinessweek News

AP News

## NaturEner to move wind turbines to protect birds

Posted on August 17, 2012 | [Twitter](#) [Facebook](#) [LinkedIn](#) [Google+](#) | [0 Comments](#)

GREAT FALLS, Mont. (AP) — A San Francisco-based wind energy company building a 126-tower wind farm on private land in north-central Montana has agreed to move 25 of the towers farther away from raptor nests.

NaturEner USA LLC and Montana Audubon announced Thursday the towers at the \$400 million Rim Rock Wind Farm will be moved a half mile away from the Kevin (KEE'-vin) Rim, identified as a key raptor area by the Bureau of Land Management. The Kevin Rim has been known to harbor up to 60 active nests of 10 raptor species in a given year, Montana Audubon said in a statement.

Montana Audubon said NaturEner agreed to make the changes after they had started construction on the wind



Rim Rock Wind Farm  
(photo: NaturEner)



Ferruginous Hawk  
nest (photo:  
Montana Audubon)

# Los Angeles Times

## Saving desert tortoises is a costly hurdle for solar projects

*BrightSource Energy has spent \$56 million so far to protect the threatened creatures, but calamities have befallen the effort.*

**March 04, 2012** | By Julie Cart, Los Angeles Times

Reporting from Ivanpah Valley, Calif. — Stubborn does not come close to describing the desert tortoise, a species that did its evolving more than 220 million years ago and has since remained resolutely prehistoric.

Its slowpoke take on biological adaptation has exposed modern vulnerabilities. The persnickety reptile is today beset by respiratory infections and prone to disease. Its only defenses are the shell on its back and the scent of its





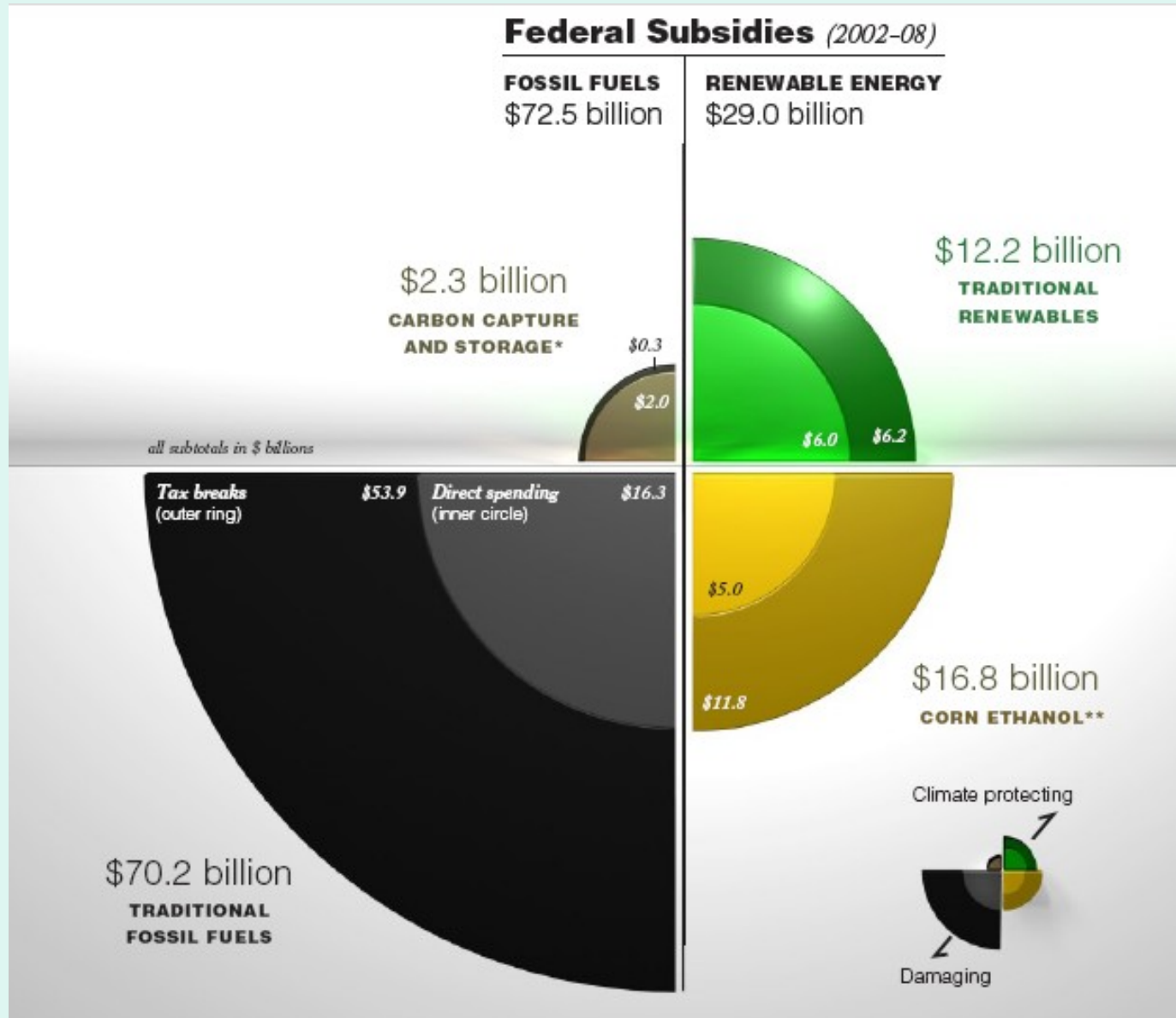
# Policies to Promote Renewables

---

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



# Fossil Fuel Subsidies



# 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 fuel consumption by the last minute of the Group of 20 summit.

The G20 communication term of inefficient fossil fuel consumption, taking into account the needs," said the secretary general.

The leaders also said they will discuss the future summits. They also agreed to remove watered-down provisions from the summit agenda.

An earlier version of the summit agenda approaches" to get a final review of the program.

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## The New York Times

### Obama Seeks to End Subsidies for Oil and Gas Companies

By HELENE COOPER and JONATHAN WEISMAN

Published: March 1, 2012 | 452 Comments

NASHUA, N.H. — With his re-election fate increasingly tied to the price Americans are paying at the gas pump, [President Obama](#) asked Congress on Thursday to end \$4 billion in subsidies for [oil](#) and gas companies and vowed to tackle the country's long-term energy issues while shunning "phony election-year promises about lower gas prices."

#### Related

[Tensions Raise Specter of Gas at \\$5 a Gallon \(March 1, 2012\)](#)

[The Next Gas Price Obama](#)

Mr. Obama, in an appearance at Nashua Community College here, took a page out of his jobs strategy of last year, calling on Americans to

## World should eradicate fossil fuel subsidies: IEA



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#### Factbox

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

#### Analysis & Opinion

[California voters back weakened climate law](#)

[Green energy aspirations for Obama's India visit](#)

#### Related Topics

[Green Business »](#)

12:18pm EST

Eliminating fossil fuel subsidies would boost the economy, environment and energy security, the International Energy Agency said on Sunday, following up on a pledge made by G20 leaders.

The IEA urged developed countries to phase out, over the medium-term, fossil fuel subsidies that encourage wasteful consumption. A G20 meeting in Seoul this week may update the list of countries.

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

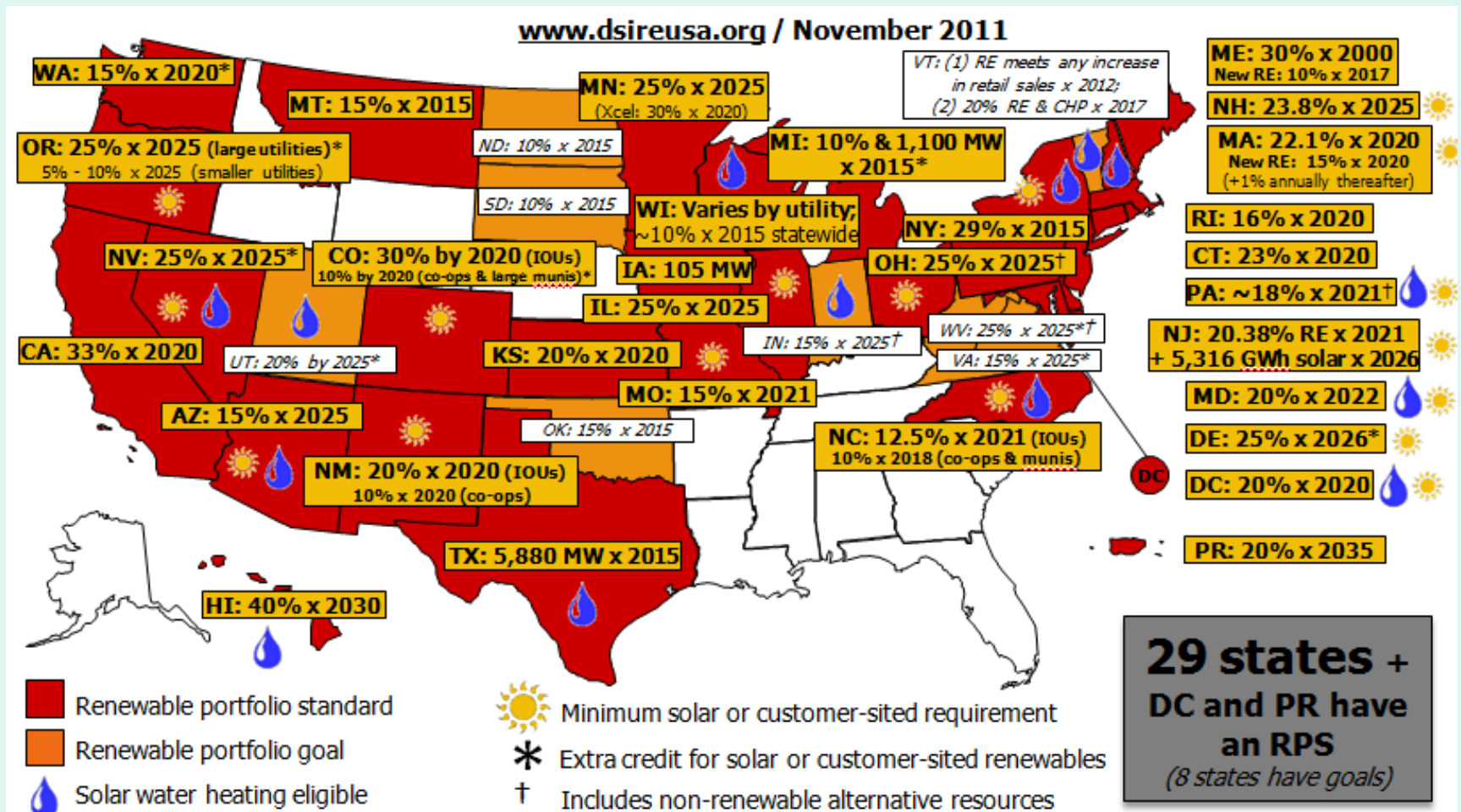
# Putting a Price on Carbon



- 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.





# Net Metering

- Requirement that utilities connect small renewable systems to the grid and “buy” excess power generated
- In Montana, net metering is available for NorthWestern Energy and MDU customers for systems up to 50 kW
- There are >1,000 net-metered systems in Montana



50 kW solar system in Missoula (Oasis Montana)

# Feed-In Tariffs

- Fixed, long-term above-market price to eligible renewable generators
- Common in Europe

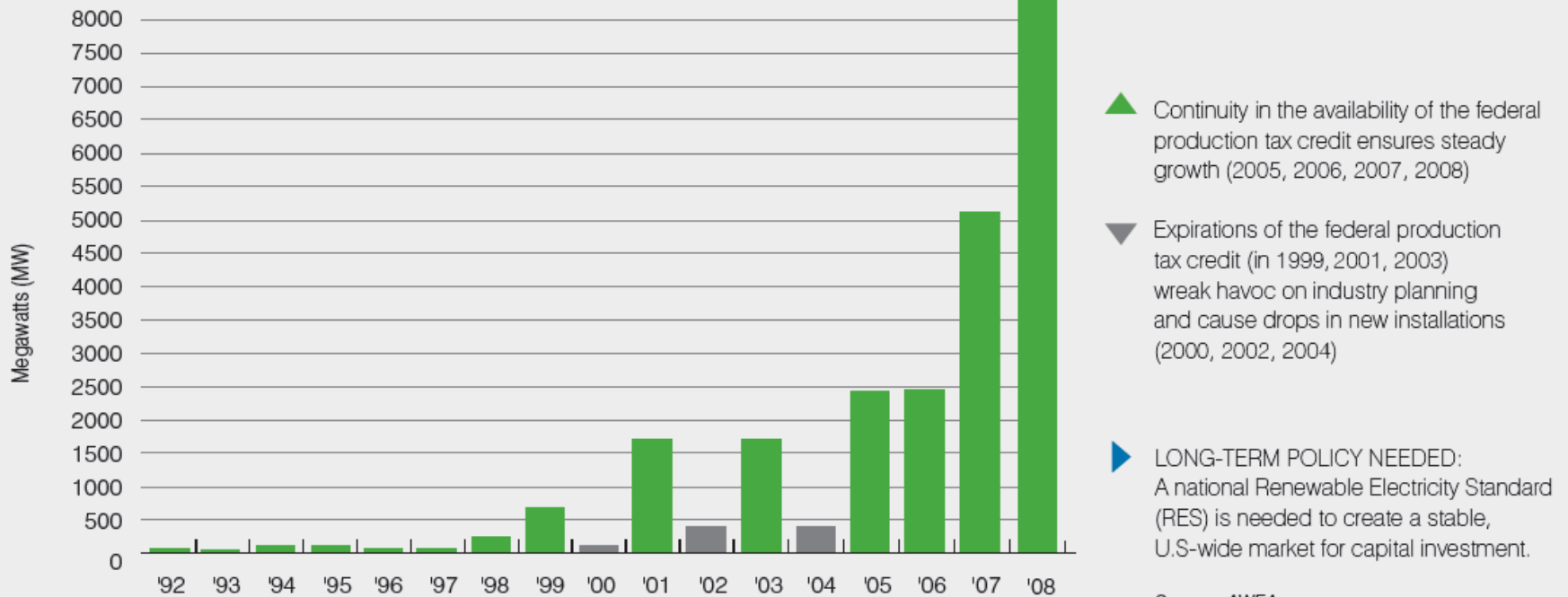
## Wind Penetrations

Denmark	21%
Portugal	18%
Spain	16%
Germany	9%
<i>United States</i>	<i>2%</i>



# Tax Credits Work

Annual Installed U.S. Wind Power Capacity



...but continuity is needed

# Montana Renewable Energy Policies and Incentives

---

- Renewable Energy Standard: 15% by 2015
- Net Metering
- Universal System Benefits (USB) Program
- Renewable Energy Tax Credits
- Alternative Energy Revolving Loan Program
- Utility Green Power Program





Diana Maneta, Executive Director, (406) 214-9405, [dmaneta@montanarenewables.org](mailto:dmaneta@montanarenewables.org)  
[www.montanarenewables.org](http://www.montanarenewables.org)