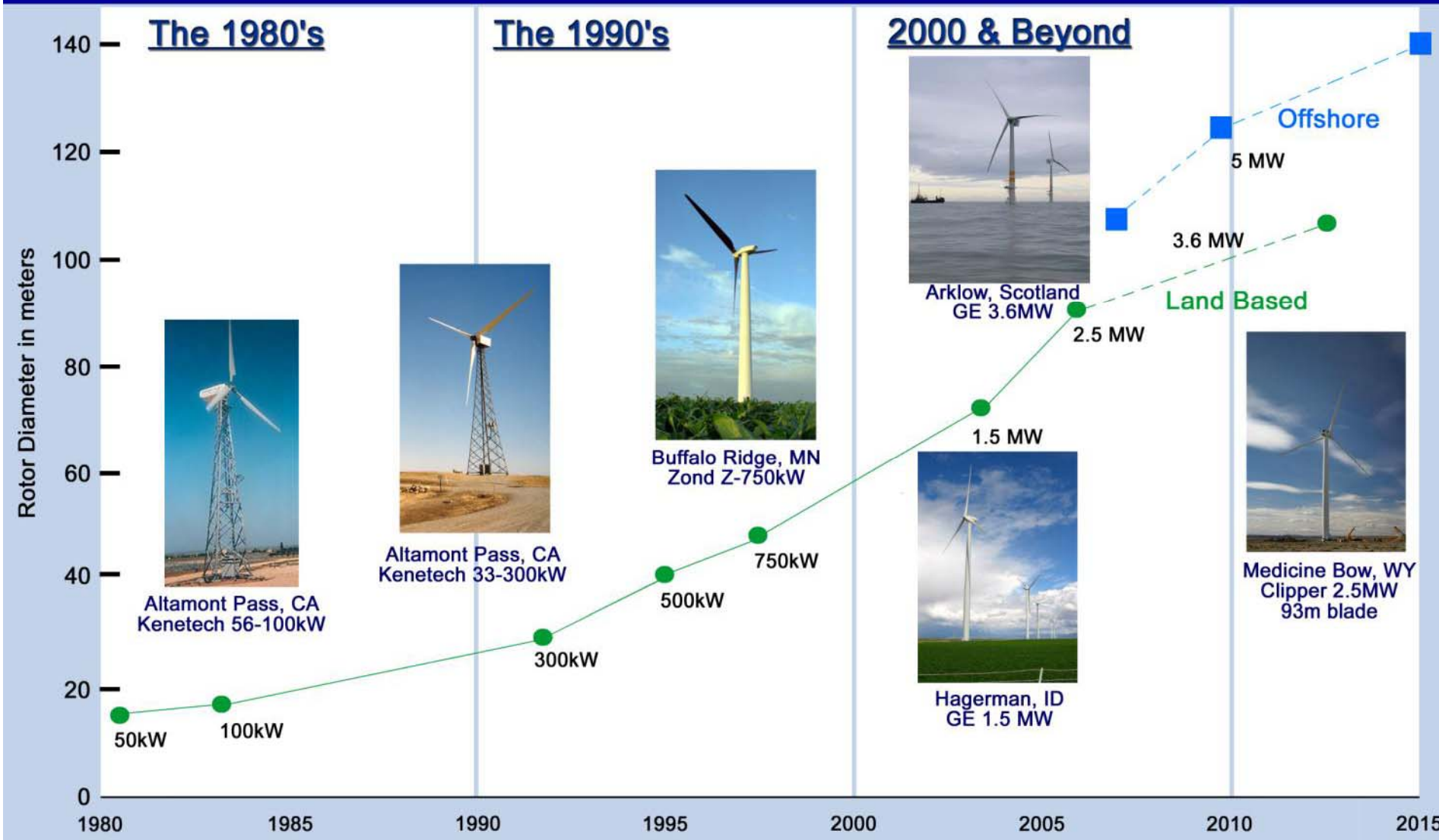
Wind Energy Update

Larry Flowers

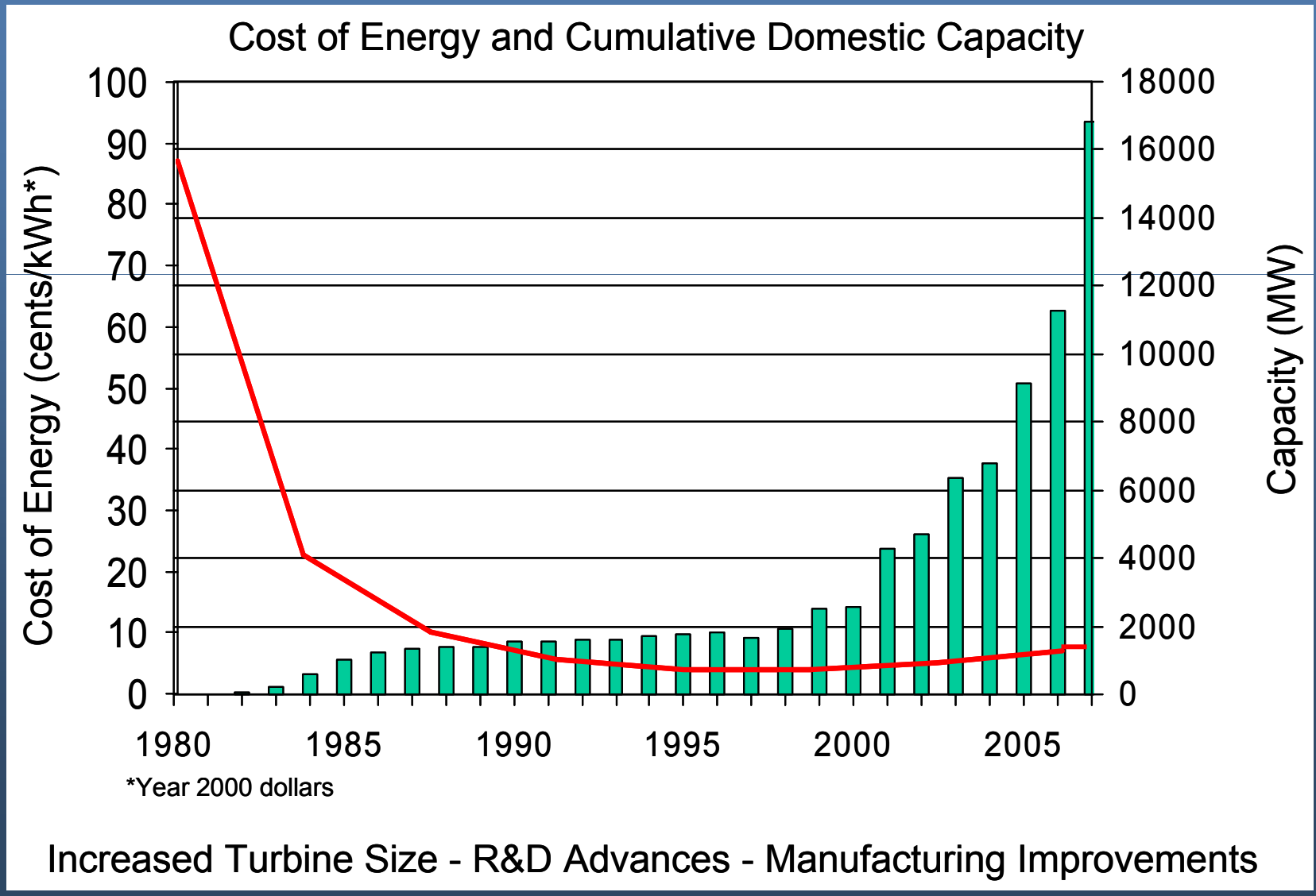
National Renewable Energy Laboratory

January 23, 2008

Evolution of U.S. Commercial Wind Technology



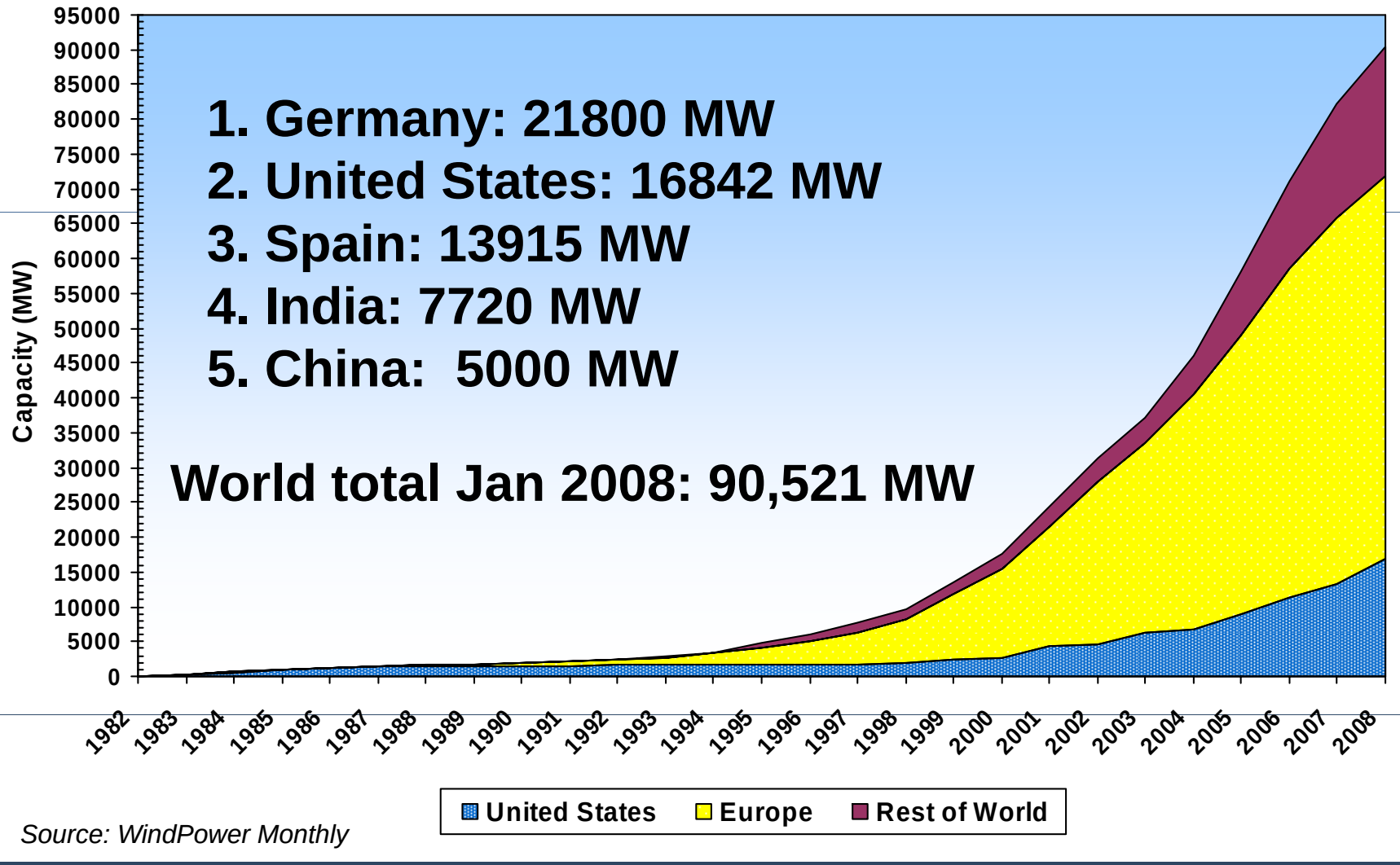
Capacity & Cost Trends



Increased Turbine Size - R&D Advances - Manufacturing Improvements

People Want Renewable Energy!

Total Installed Wind Capacity



Source: WindPower Monthly

U.S. Leads World in Annual Wind Capacity Additions; Second in Cumulative Capacity

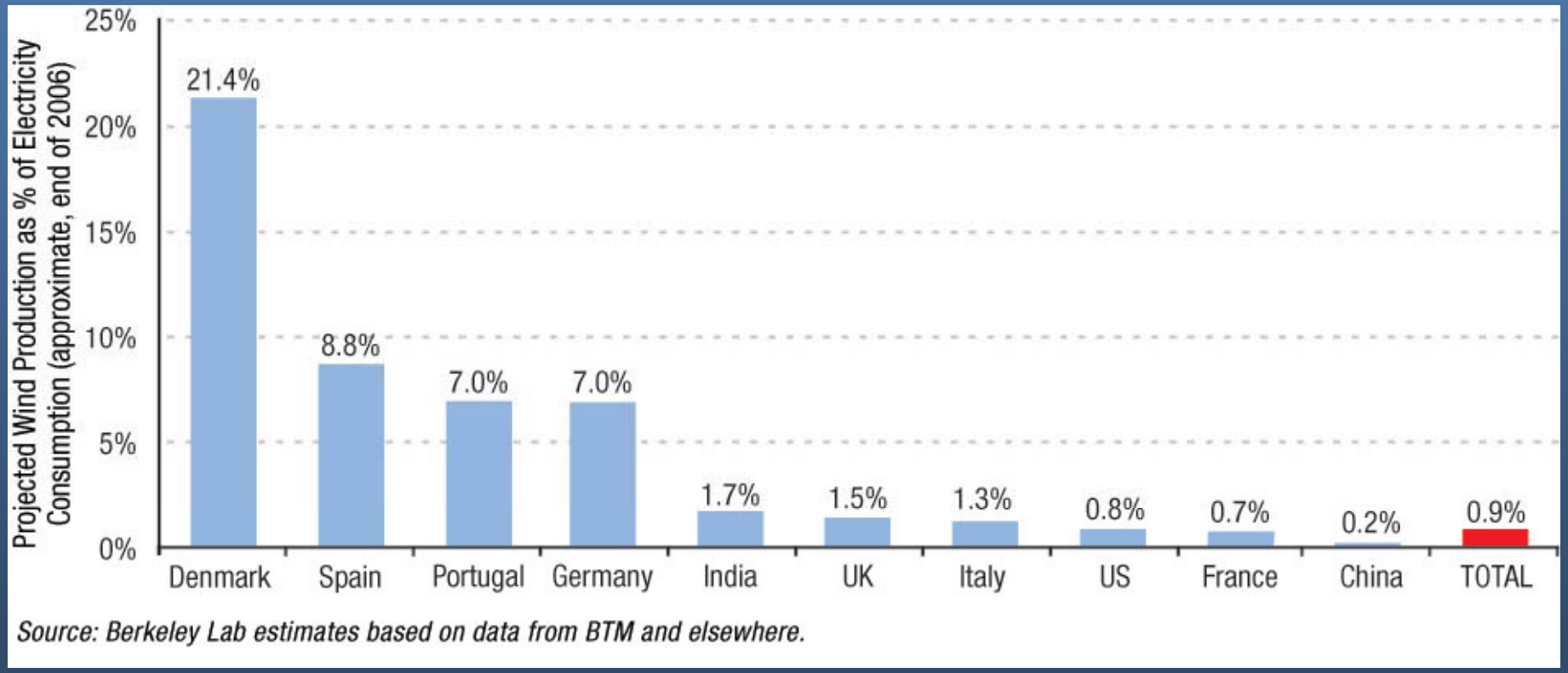
International Rankings of Wind Power Capacity

Cumulative Capacity (end of 2007, MW)	
Germany	21,800
United States	16,842
Spain	13,915
India	7,720
China	5,000
Denmark	3,132
France	2,624
Rest of World	19,488
Total	**90,521**

Incremental Capacity (2007, MW)	
United States	5,144
China	2,406
Spain	2,300
India	1,450
Germany	1,178
France	1,155
Portugal	494
Rest of World	5,248
Total	**19,375**

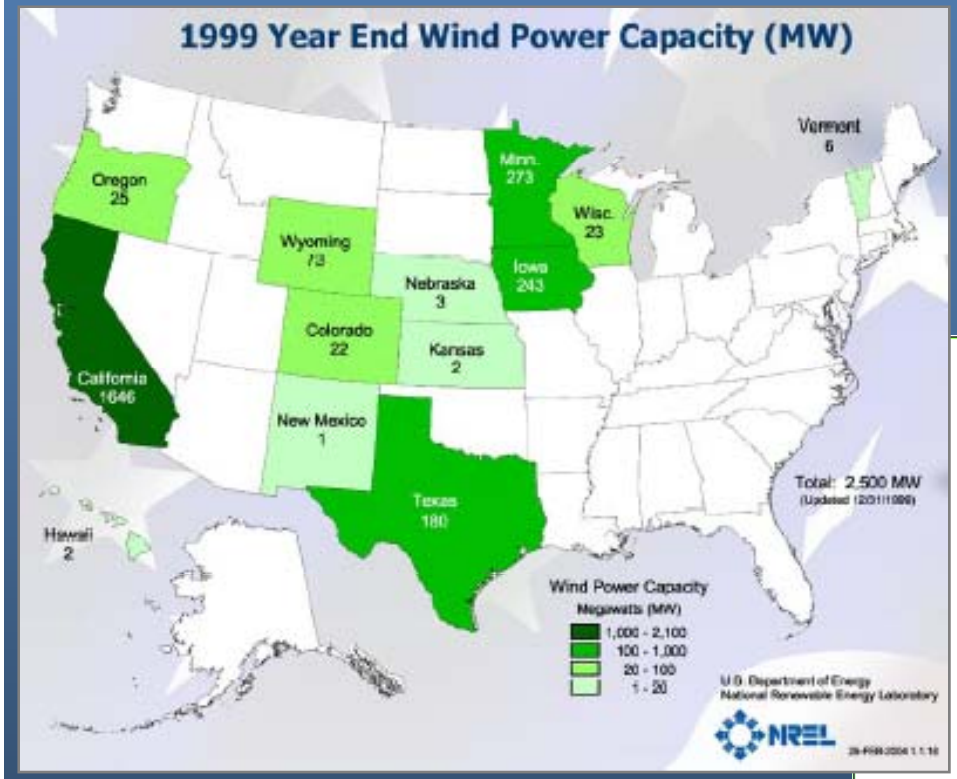
Data source: Windpower Monthly Windicator, January 2008

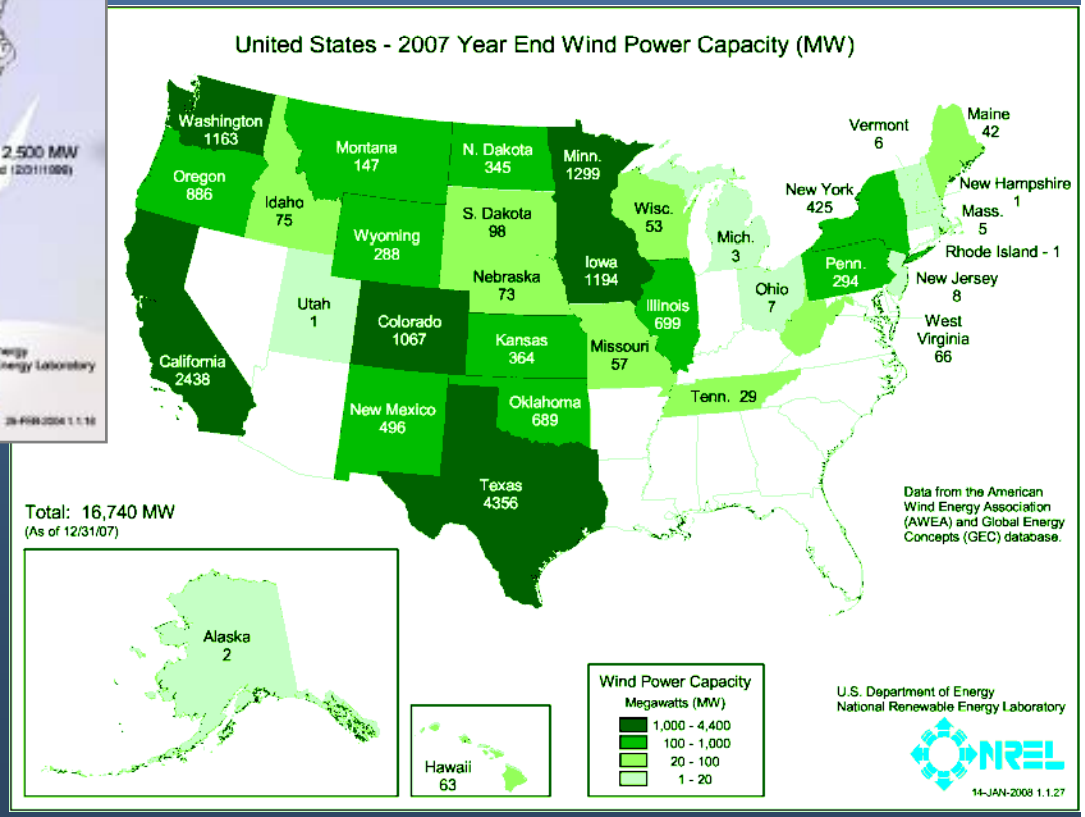
U.S Lagging Other Countries for Wind As a Percentage of Electricity Consumption



Source: Berkeley Lab estimates based on data from BTM and elsewhere.

Installed Wind Capacities ('99 – Dec '07*)

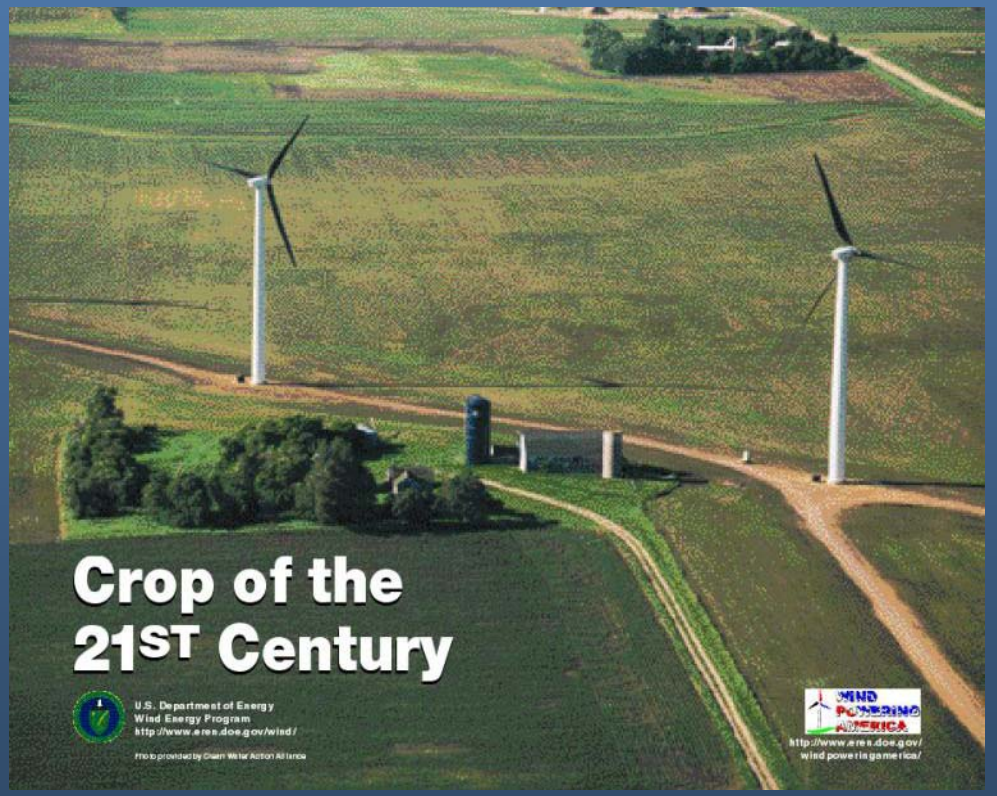




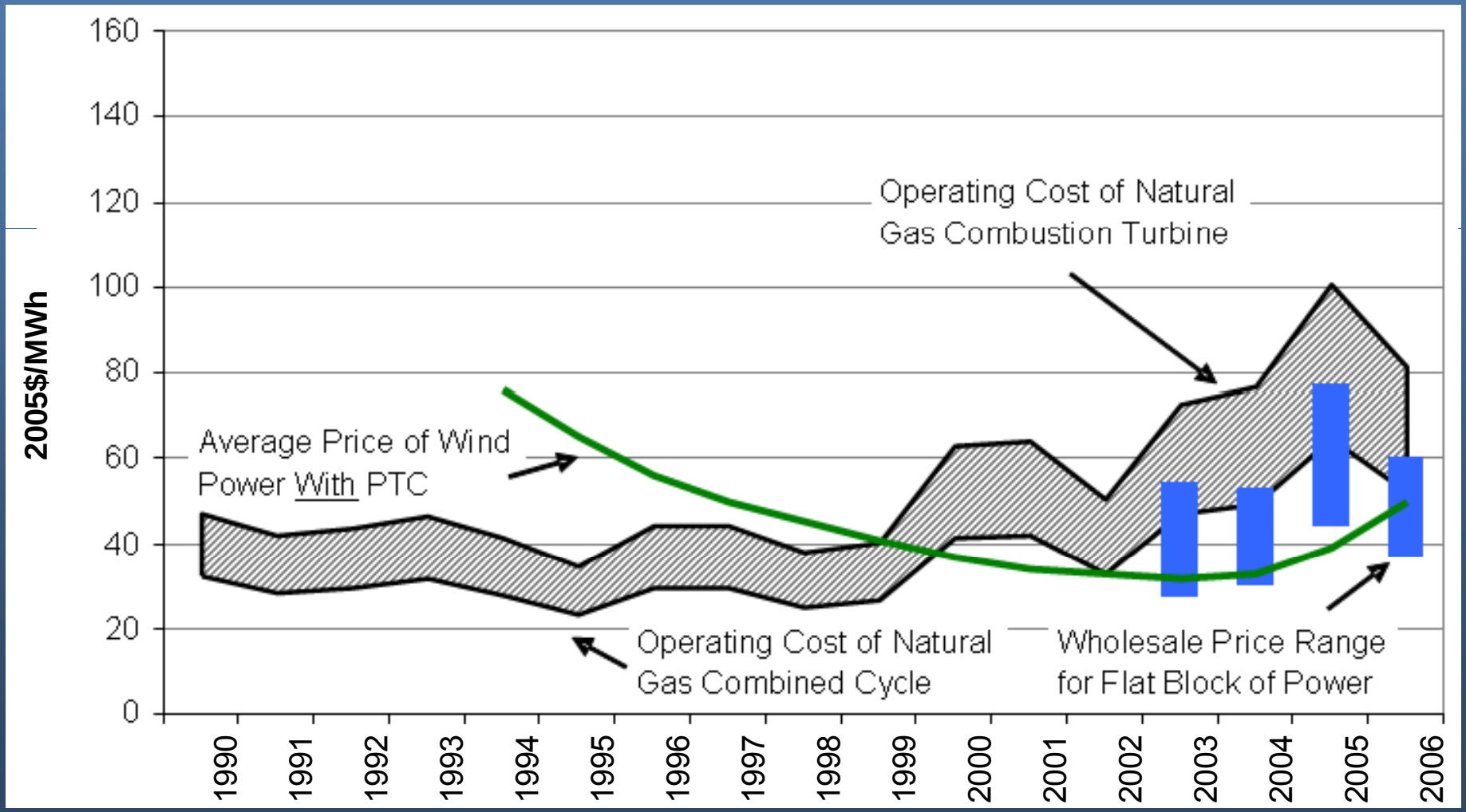
*Preliminary data

Drivers for Wind Power

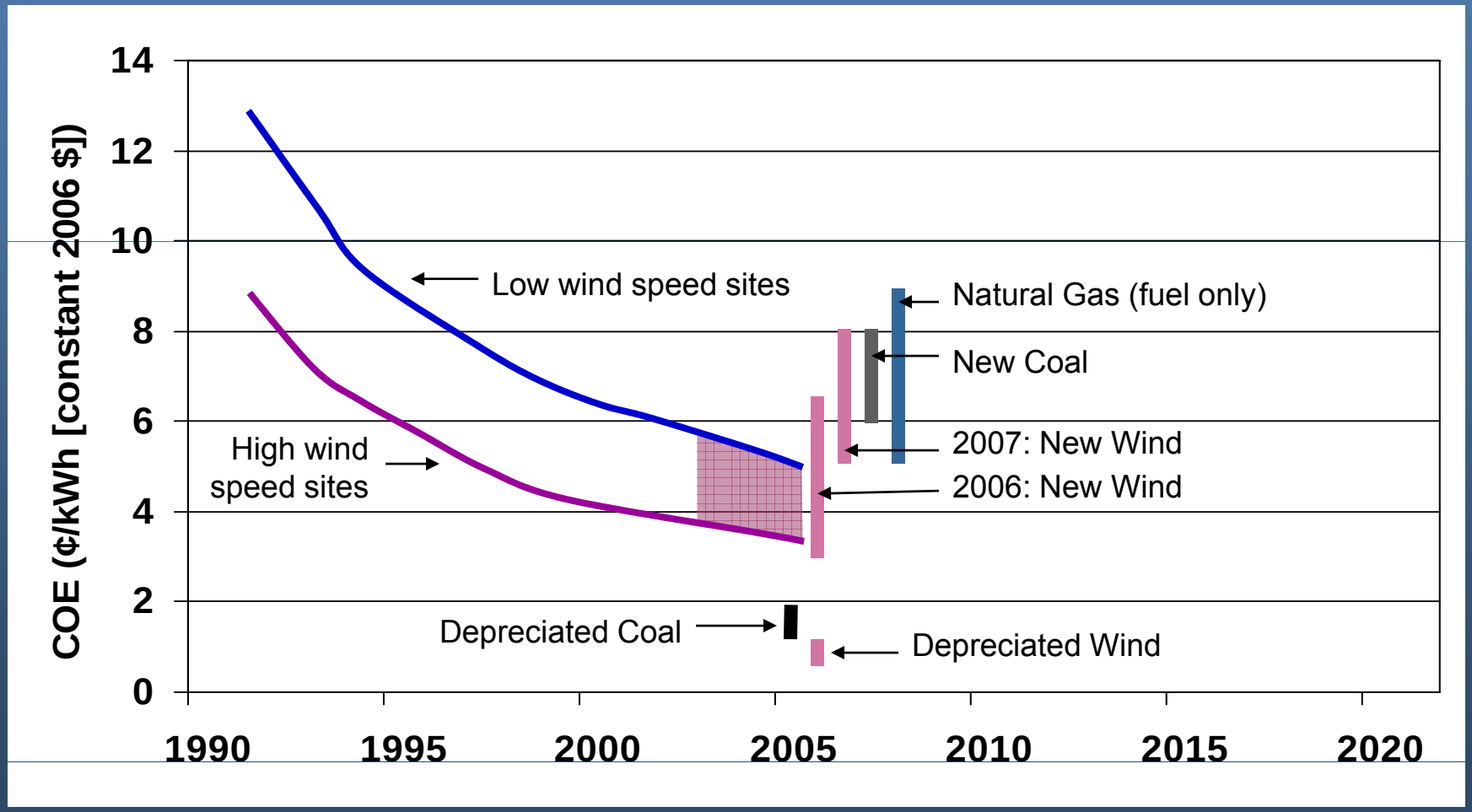
- Declining Wind Costs
- Fuel Price Uncertainty
- Federal and State Policies
- Economic Development
- Public Support
- Green Power
- Energy Security
- Carbon Risk

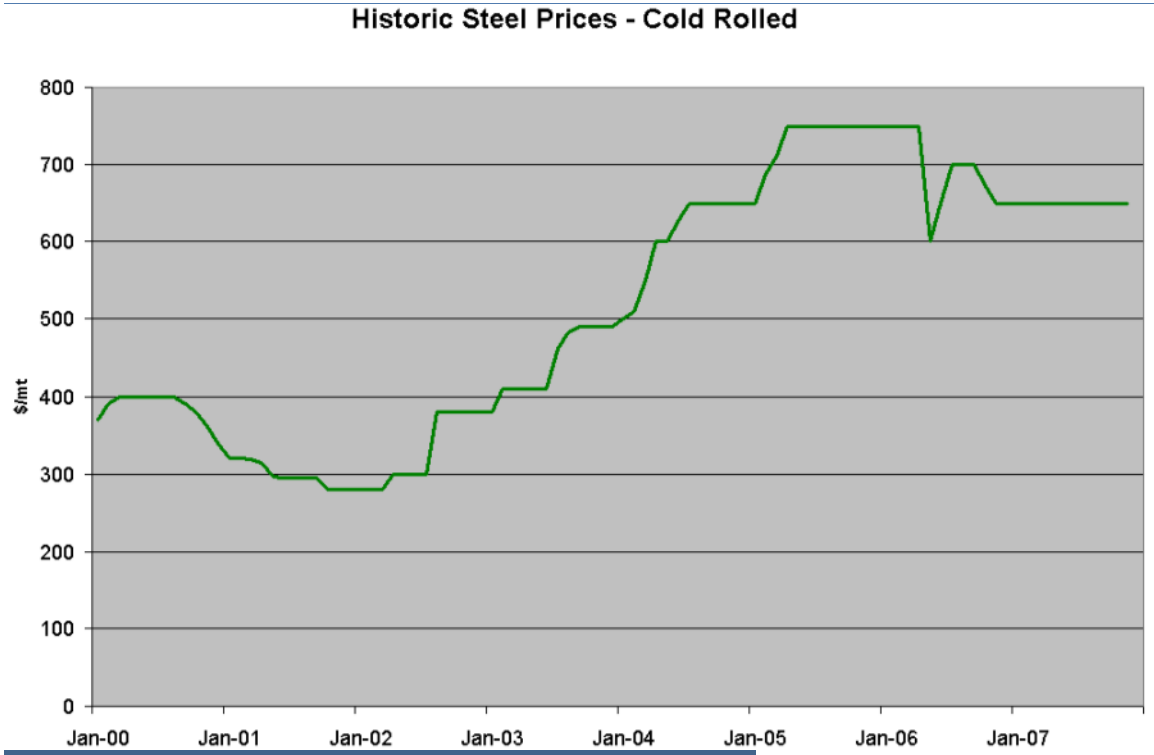


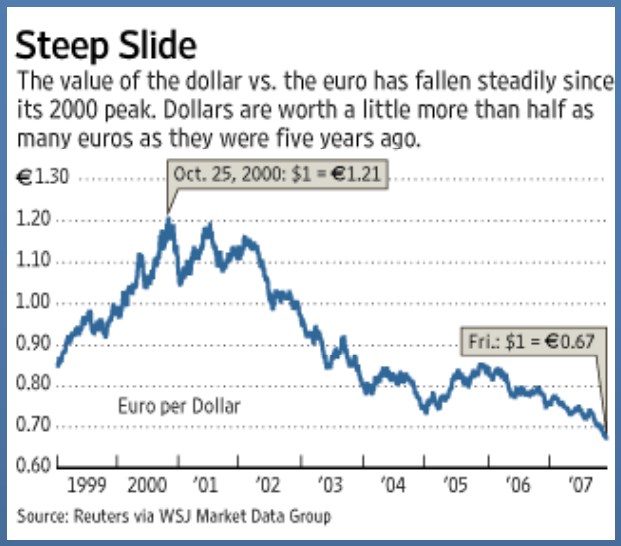
Comparative Generation Costs



Wind Cost of Energy

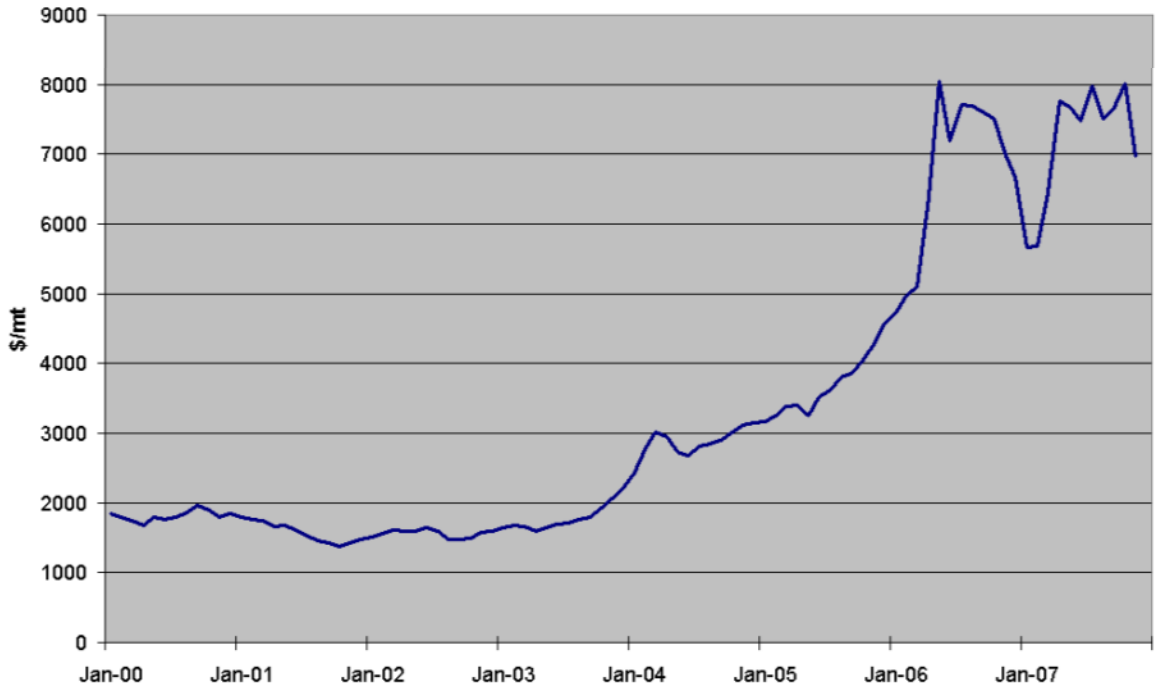




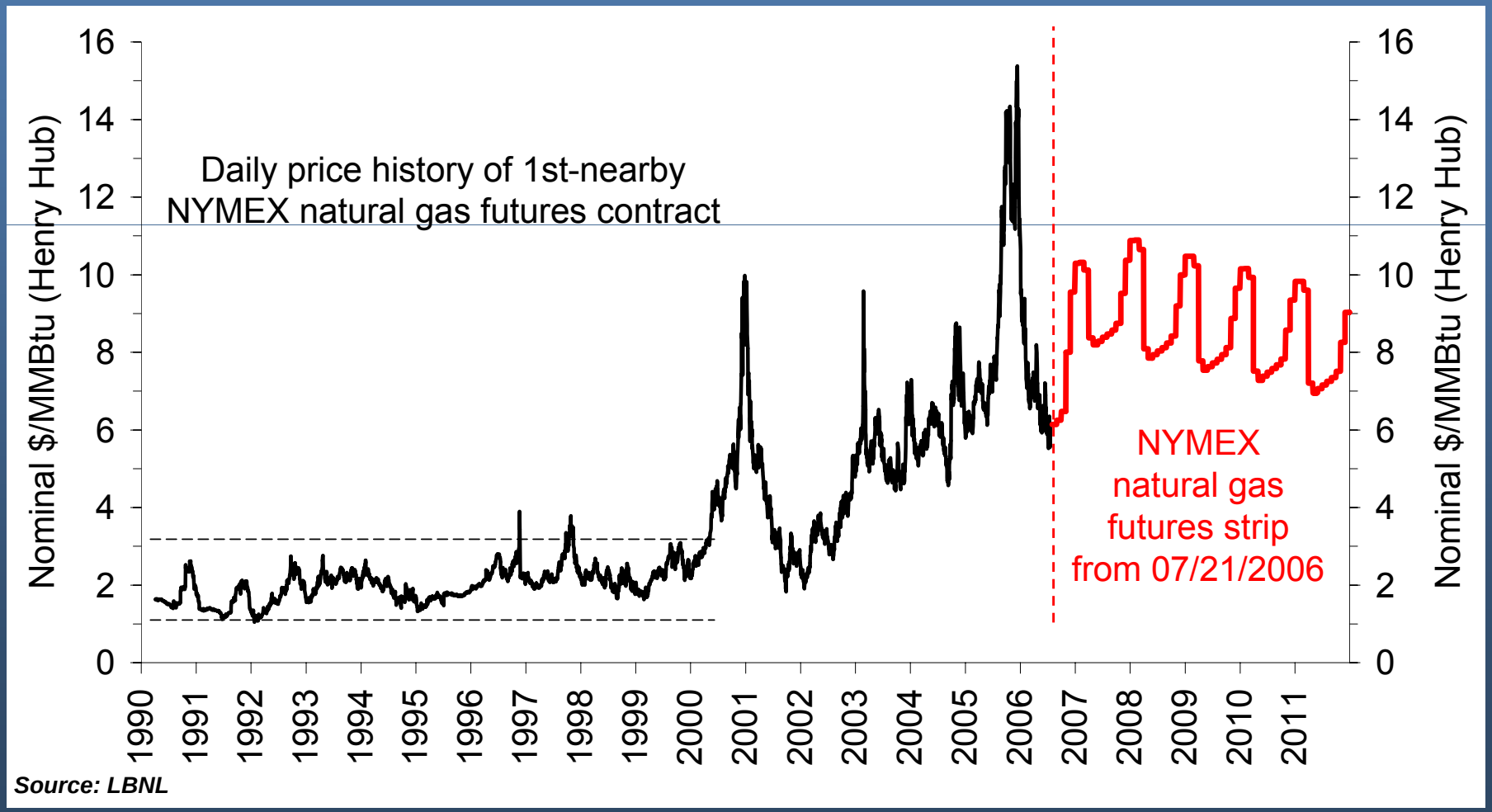


Wind Cost Drivers

Copper & Steel Price Source: World Bank, Commodity Price Data

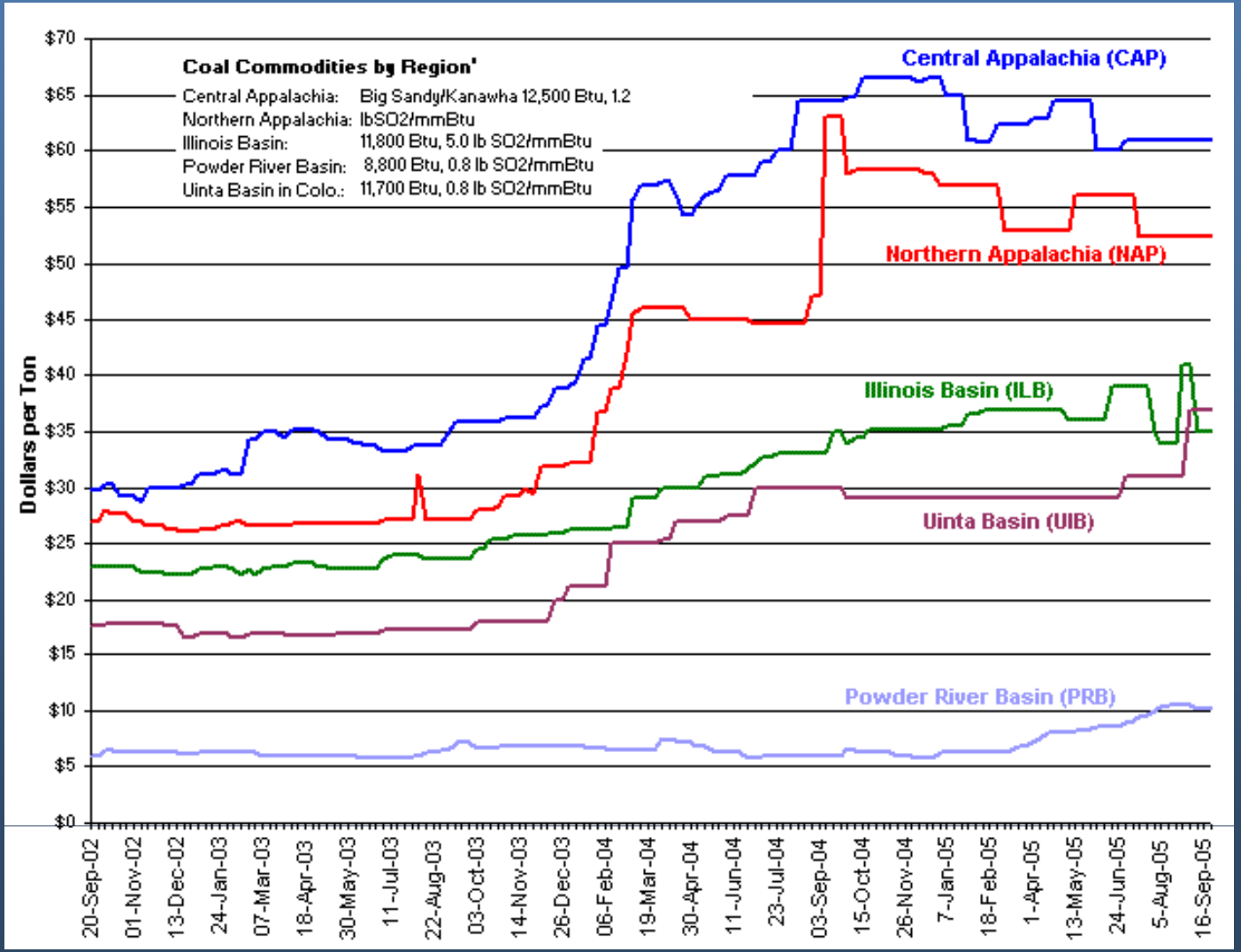


Natural Gas – Historic Prices



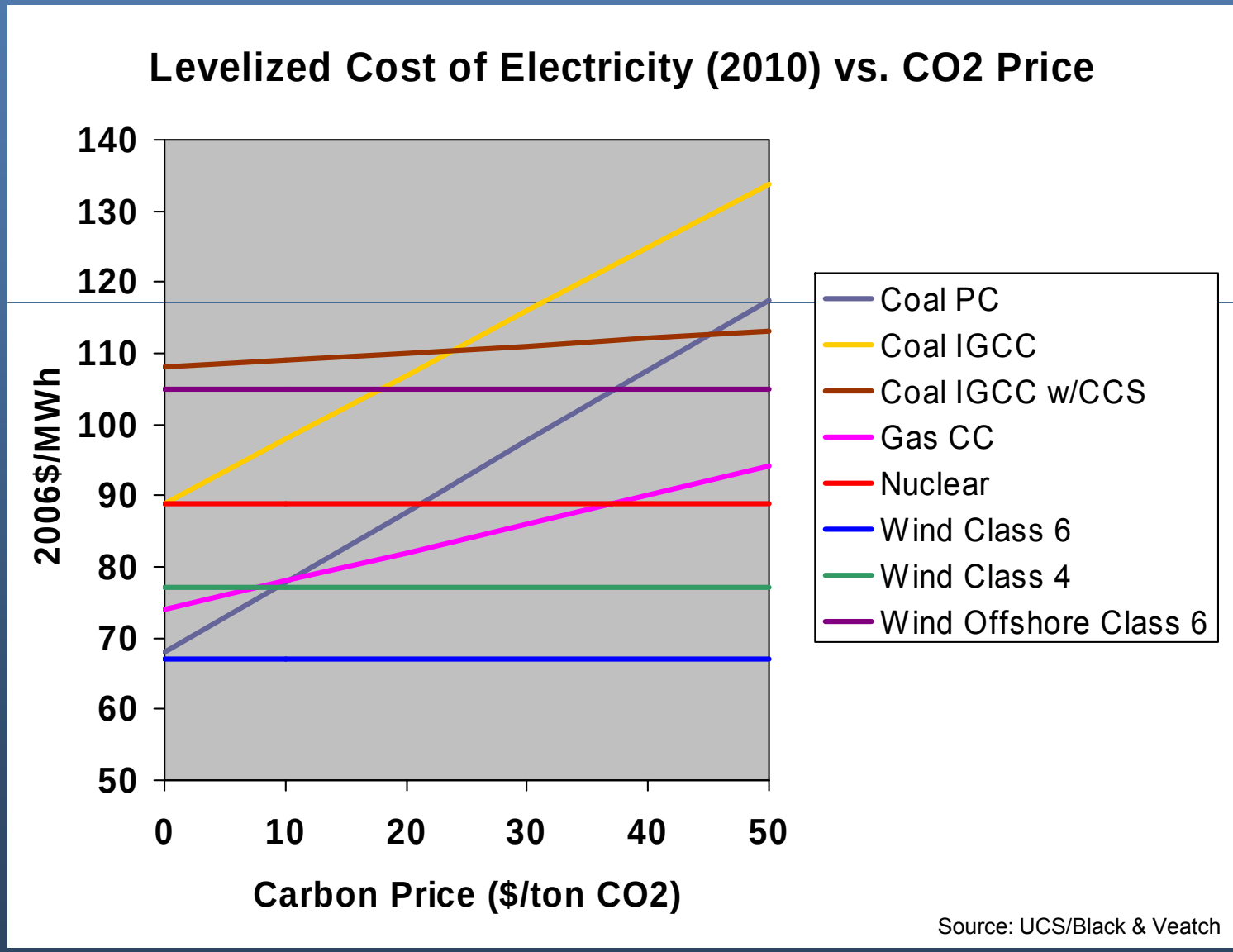
Source: LBNL

Historical Coal Prices



Source: EIA

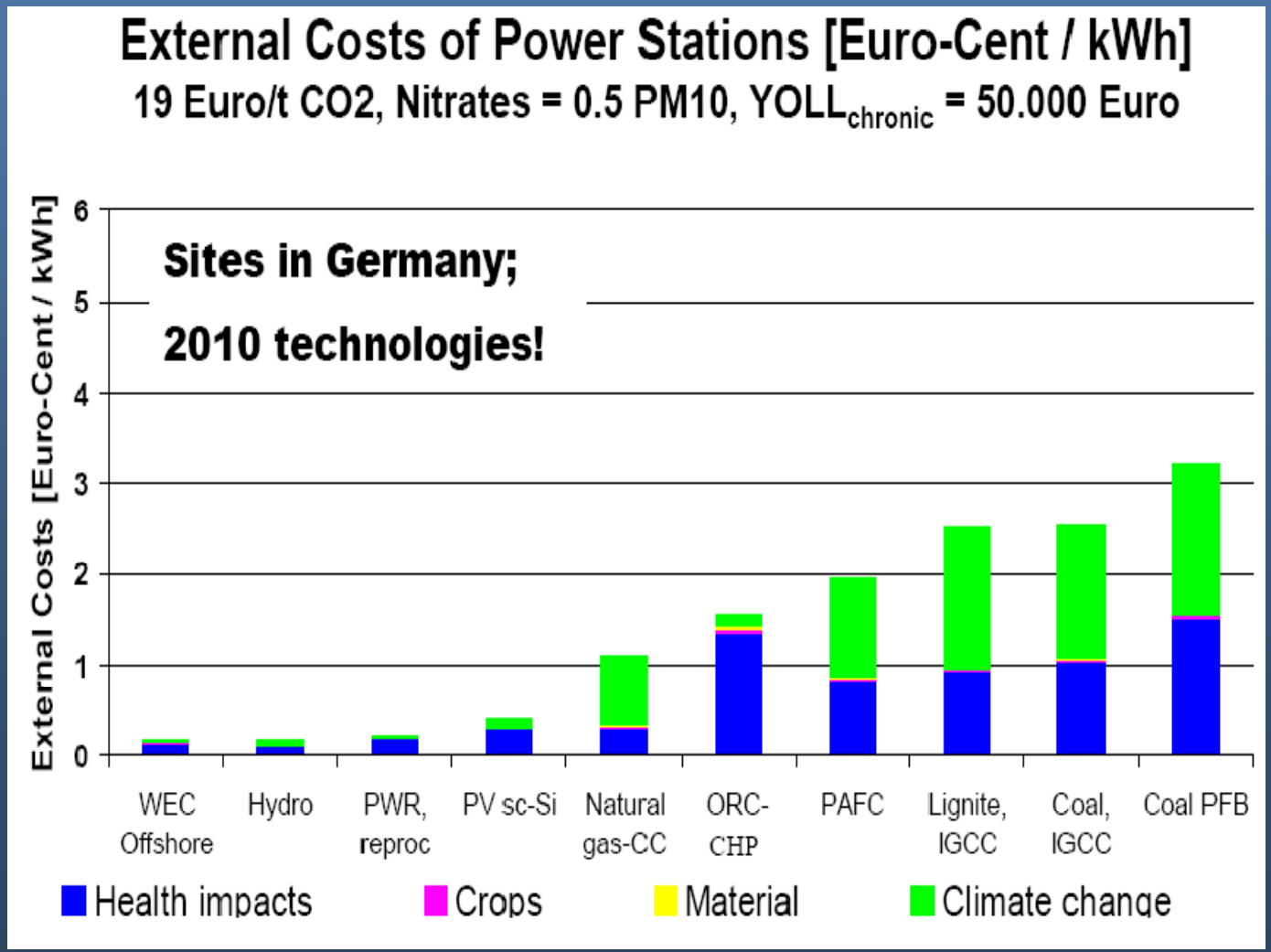
CO_2 prices significantly increase the cost of coal



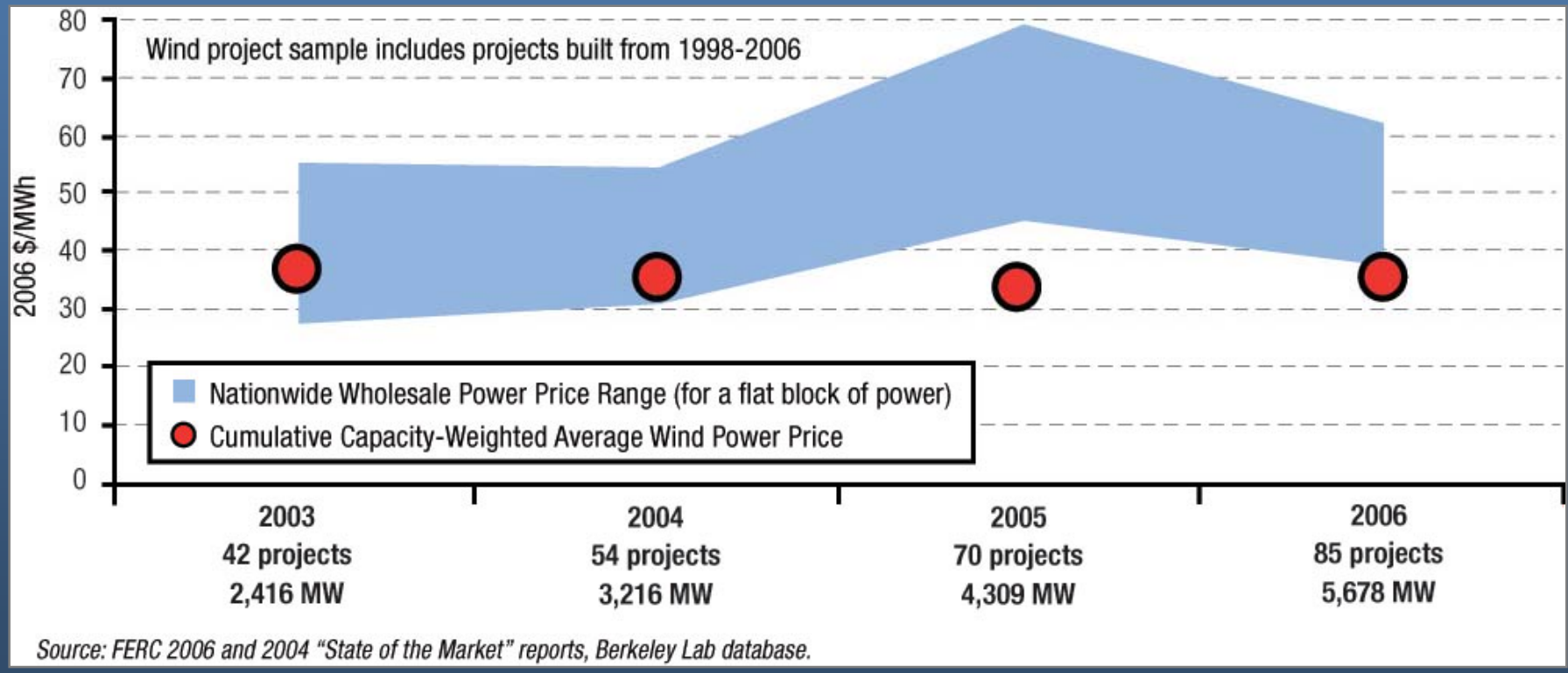
Source: UCS/Black & Veatch

Major Market Distortion: External Costs of Fossil Fuels not Reflected in Pricing

(The PTCs are a bargain)

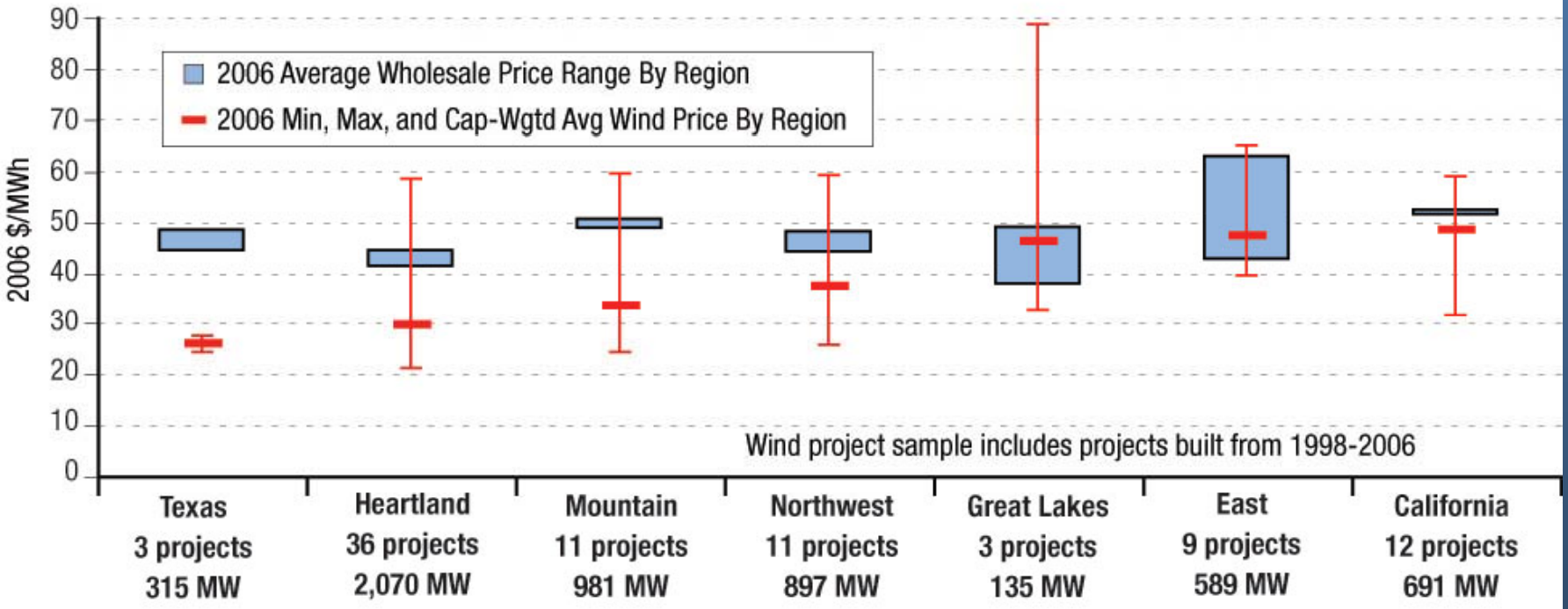


Nationally, Wind Has Been Competitive with Wholesale Power Prices in Recent Years



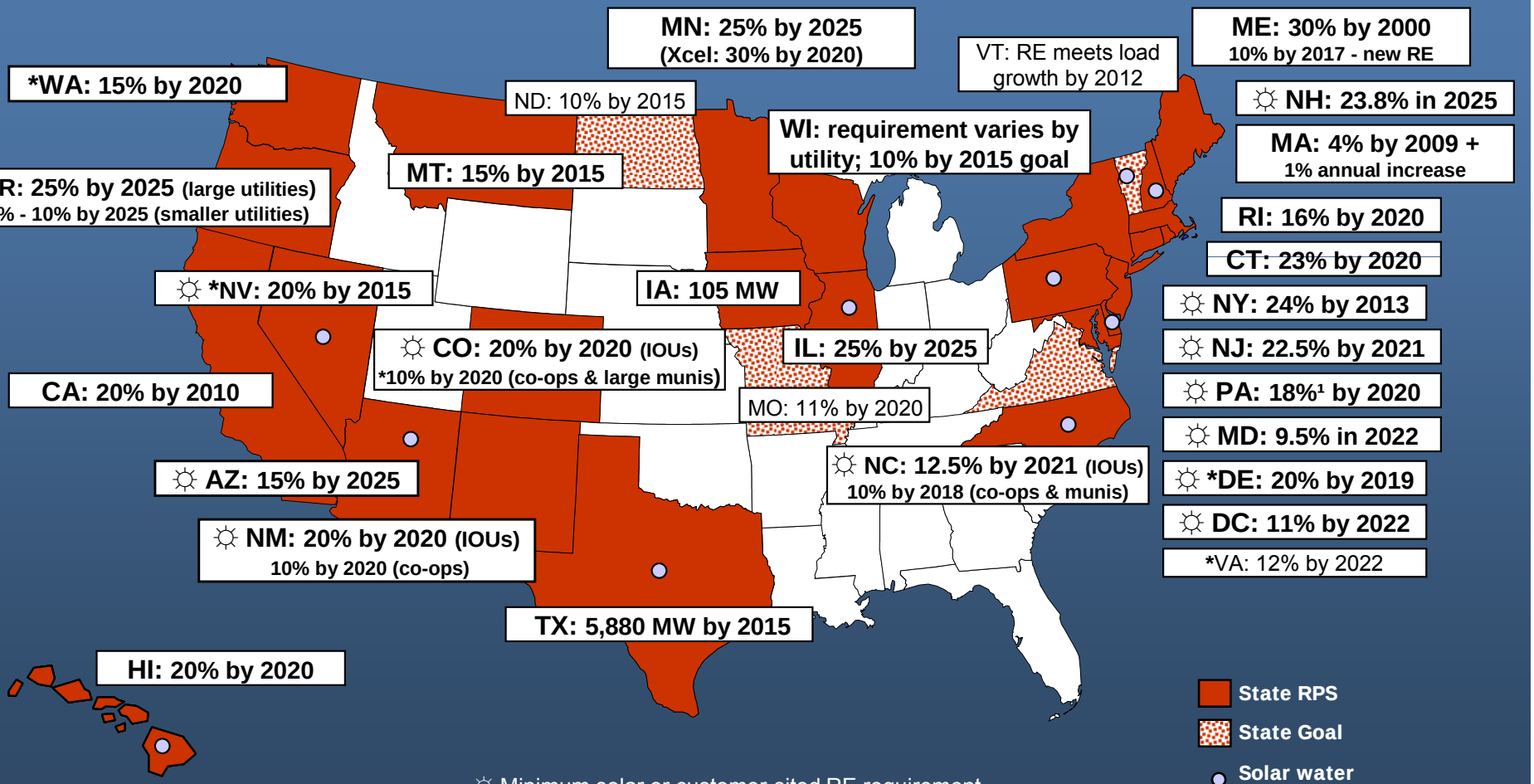
Source: FERC 2006 and 2004 "State of the Market" reports, Berkeley Lab database.

In 2006, Wind Projects Built Since 1997 Were Competitive with Wholesale Power Prices in Most Regions



Source: FERC 2006 "State of the Market" report, Berkeley Lab database.

Renewables Portfolio Standards



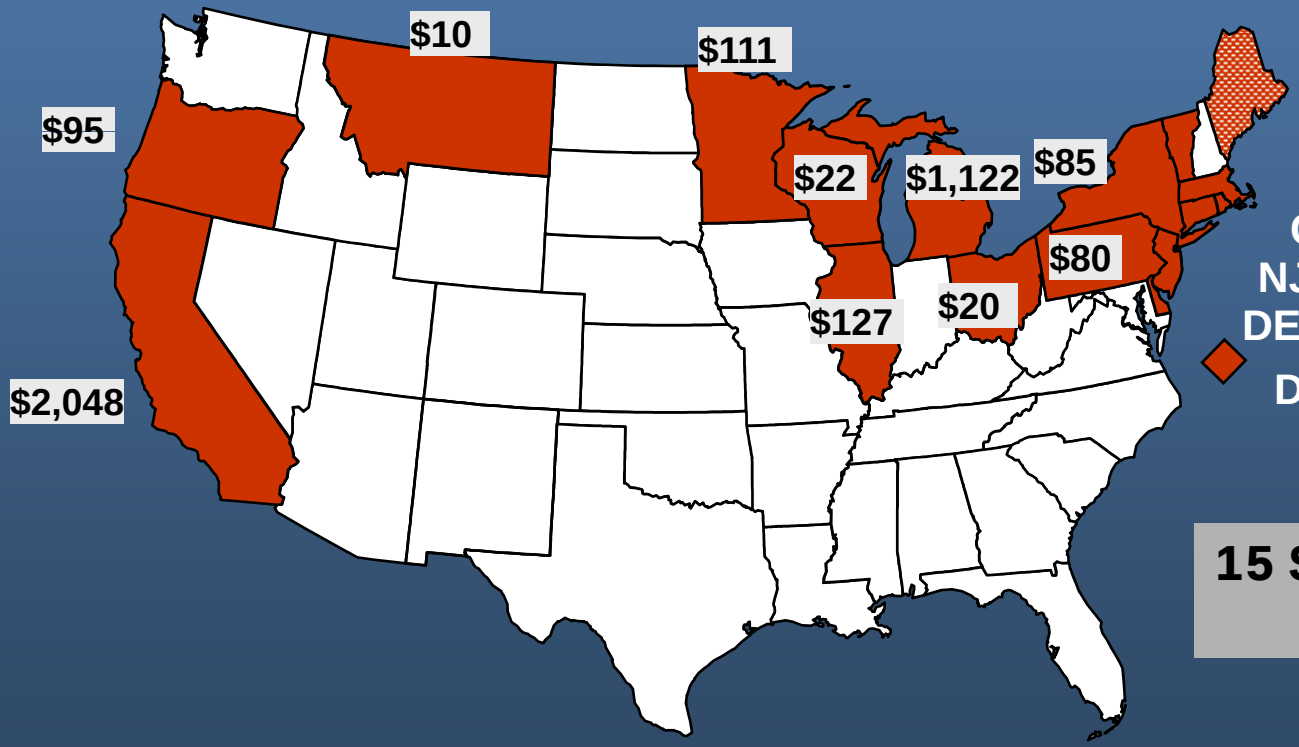
☼ Minimum solar or customer-sited RE requirement
* Increased credit for solar or customer-sited RE
¹PA: 8% Tier I / 10% Tier II (includes non-renewables)

DSIRE: www.dsireusa.org

January 2008

Public Benefit Funds for Renewables

Cumulative 1998 – 2017 (Million $)

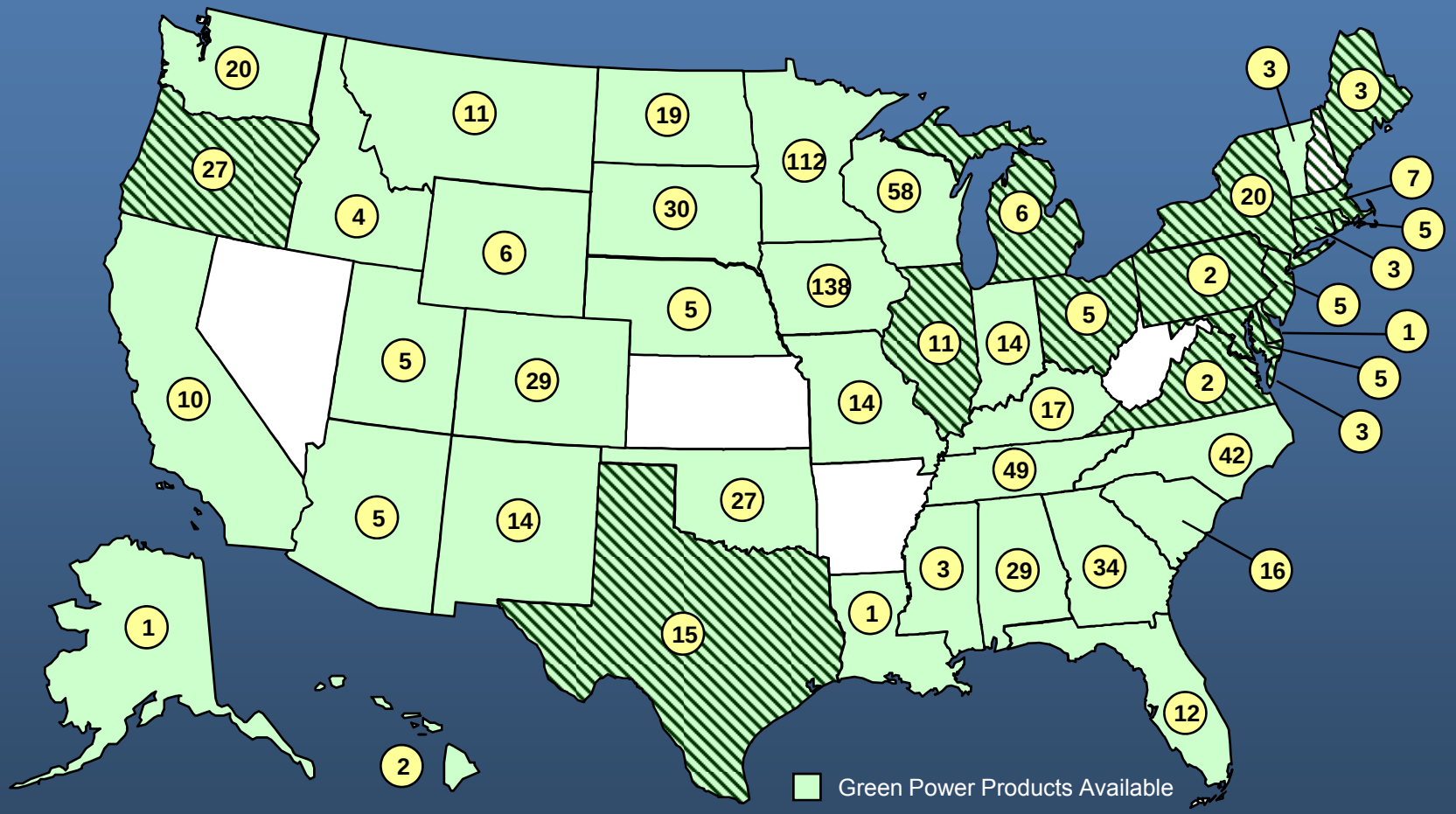


15 State Funds + DC
$4 B by 2017

Funded by Voluntary Contributions

www.dsireusa.org
July 2007

States with Green Power Programs



Source: National Renewable Energy Laboratory (October 2007)

Wind Energy Investors

SIEMENS

bp BP Solar

JOHN DEERE

FPL

Vestas

AEP AMERICAN ELECTRIC POWER

Gamesa

Xcel Energy

AES

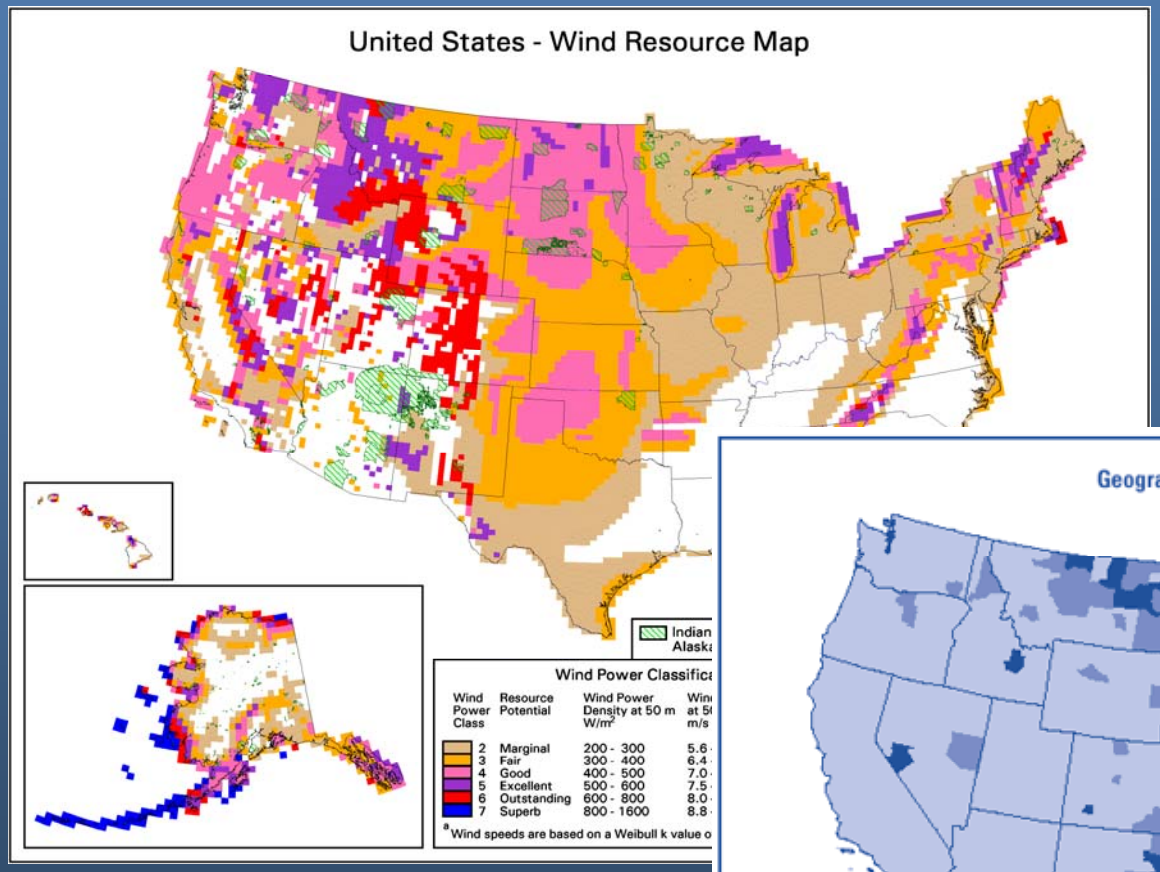
MIDAMERICAN ENERGY HOLDINGS COMPANY

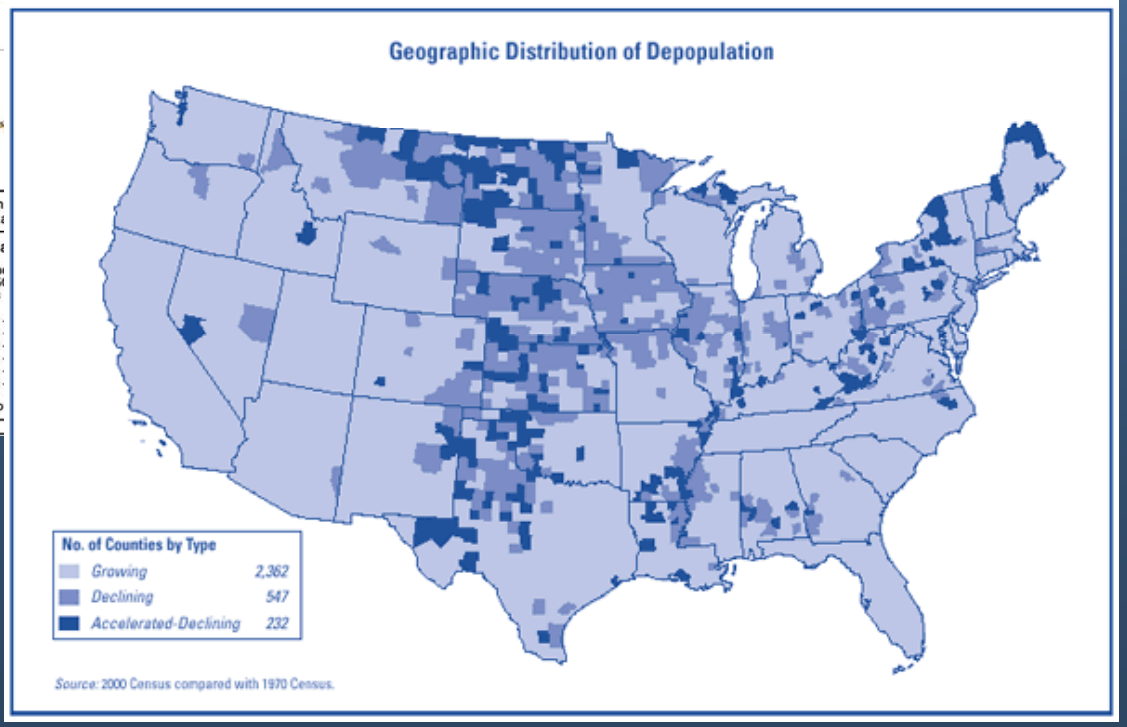
Goldman Sachs

Economic Development Impacts

- **Land Lease Payments**: 2-3% of gross revenue $2500-4000/MW/year
- **Local property tax** revenue: ranges widely - $300K-1700K/yr per 100MW
- 100-200 **jobs**/100MW during construction
- 6-10 permanent O&M **jobs** per 100 MW
- Local construction and service industry: concrete, towers usually done locally

Windy Rural Areas Need Economic Development





Case Study: Texas

Utilities and wind companies invested $1B in 2001 to build 912 MW of new wind power, resulting in:

- **2,500 quality jobs with a payroll of $75M**
- $13.3M in tax revenues for schools and counties
- $2.5M in 2002 royalty income to landowners
- Another 2,900 indirect jobs as a result of the multiplier effect
- $4.6M increase in Pecos County property tax revenue in 2002

Case Study: Minnesota

107-MW Minnesota wind project

- **$500,000/yr in lease payments to farmers**
- $611,000 in property taxes in 2000 = 13% of total county taxes
- 31 long-term local jobs and $909,000 in income from O&M (includes multiplier effect)

Case Study: Iowa

240-MW Iowa wind project

- $640,000/yr in lease payments to farmers ($2,000/turbine/yr)
- $2M/yr in property taxes
- $5.5M/yr in O&M income
- **40 long-term O&M jobs**
- **200 short-term construction jobs**
- Doesn't include multiplier effect

Case Study: New Mexico

- 204-MW wind project built in 2003 in DeBaca and Quay counties for PNM
- 150 construction jobs
- 12 permanent jobs and $550,000/yr in salaries for operation and maintenance
- $550,000/year in lease payments to landowners
- **$450,000/year in payments in lieu of taxes to county and school districts**
- Over $40M in economic benefits for area over 25 years

Photo: PNM

Source: PNM, New Mexico Wind Energy Center Quick Facts, 2003.

Case Study: Hyde County, South Dakota

40-MW wind project in South Dakota creates $400,000 - $450,000/yr for Hyde County, including:

- More than $100,000/yr in annual lease payments to farmers ($3,000 - $4,000/turbine/yr)
- $250,000/yr in property taxes (25% of Highmore's education budget)
- 75 -100 construction jobs for 6 months
- 5 permanent O&M jobs
- Sales taxes up more than 40%
- Doesn't include multiplier effect

Case Study: Prowers County, Colorado

- 162-MW Colorado Green Wind Farm (108 turbines)
- $200M+ investment
- 400 construction workers
- 14-20 full-time jobs
- Land lease payments $3000-$6000 per turbine
- **Prowers County 2002 assessed value $94M; 2004 assessed value +33% (+$32M)**
- **Local district will receive 12 mil tax reduction**
- Piggyback model

"Converting the wind into a much-needed commodity while providing good jobs, the Colorado Green Wind Farm is a boost to our local economy and tax base."

John Stulp, county commissioner, Prowers County, Colorado

Colorado – Economic Impacts

from 1000 MW of new wind development

Wind energy's economic "ripple effect"

Direct Impacts

Payments to Landowners:
- $2.7 Million/yr

Local Property Tax Revenue:
- $11 Million/yr

Construction Phase:
- 1,400 new jobs
- $189 M to local economies

Operational Phase:
- 200 new long-term jobs
- $21 M/yr to local economies

Indirect & Induced Impacts

Construction Phase:
- 1,250 new jobs
- $130 M to local economies

Operational Phase:
- 200 local jobs
- $20 M/yr to local economies

Totals (construction + 20yrs)

Total economic benefit = $1.1 billion

New local jobs during construction = 2,650

New local long-term jobs = 400

All jobs rounded to the nearest 50 jobs; All values greater than $10 million are rounded to the nearest million

Construction Phase = 1-2 years
Operational Phase = 20+ years

Local Ownership Models

- Minnesota farmer cooperative (Minwind)
- FLIP structure
- Farmer-owned small wind
- Farmer-owned commercial-scale

© L. Kennedy

Environmental Benefits

- No SOx or NOx
- No particulates
- No mercury
- No CO2
- No water

amid dry skies, wells

Eastern plains farmers confronted by uncertain future as drought, cities' relentless thirst threaten agriculture

By Jerd Smith ■ Photos by Darin McGregor ■ Rocky Mountain News

DENVER • MONDAY, JULY 9, 2007 • 50 CENTS

Border Street: A new spirit despite immigration bill's demise.

Dive instructor pulls elderly man from be

One-tank road trips can be a gas no matter w

Rocky Mountai

SHADOW OF

New laws, legal fights and a wells and changed a way of For many, the next steps re

Farms high and dry

■ **State shutting 400 wells** to preserve South Platte; 200 growers could lose crops. 4A

ROCKY MOUNTAIN NEWS SATURDAY 2

Western droughts could become norm

Climate models

If that happens, the state will

The new report projects a

NNING DRY

Water crisis grows dire

Discussing Water Rights, A Western Pastime

Farmers sweating over lack of water

Growers mop brows after state edict to shut down wells

By Jerd Smith
ROCKY MOUNTAIN NEWS

The state ordered more than 400 powerful irrigation wells shut down this week to protect the South Platte River, triggering a crisis for about 200 farms from Brighton to Fort Morgan.

"It's the toughest decision I've ever had to make," said State Engineer Hal Simpson. Colorado's top

Arnie Good, 57 the well that ir been idled. At t

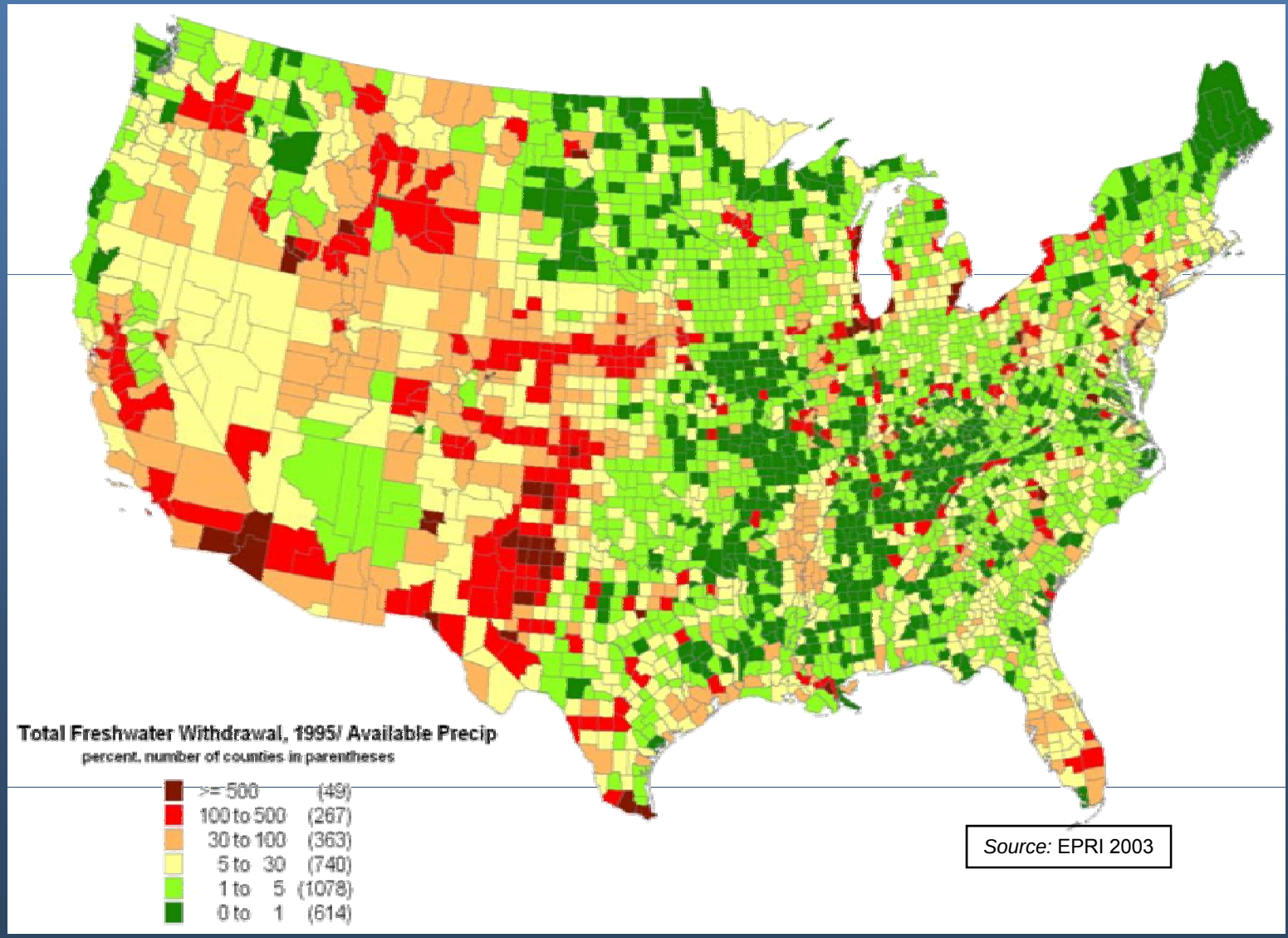
South Platte irrigation wells turned off

More than 400 irrigation wells used by farmers are being shut down because they can't meet the requirements of a new law designed to protect the South Platte River. The irrigation wells rely on the same shallow aquifer that helps supply the river.

Source: USGS

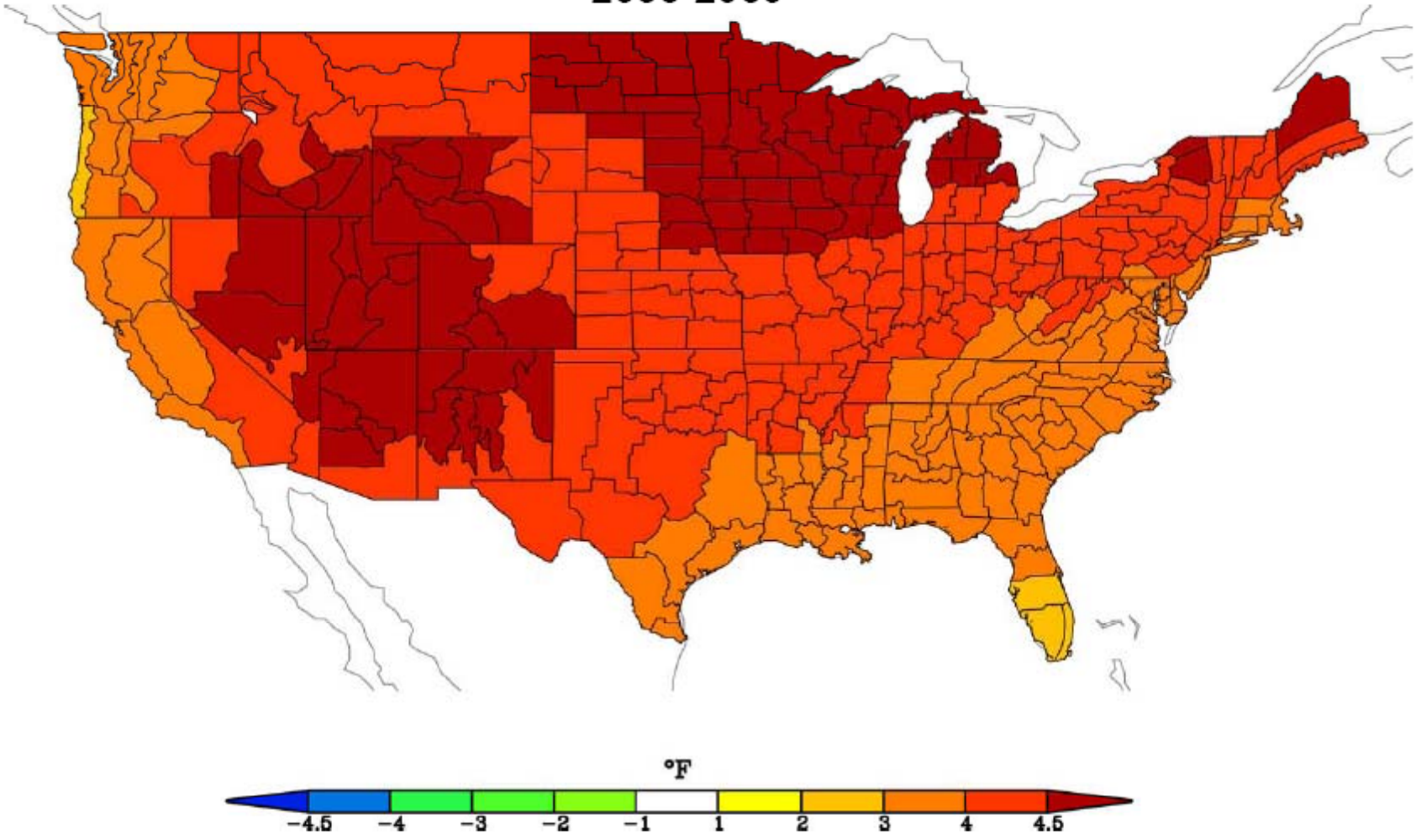
CHARLES CHAMBERLIN/ROCKY MOUNTAIN NEWS

Sustainable Withdrawal Of Freshwater Is National Issue



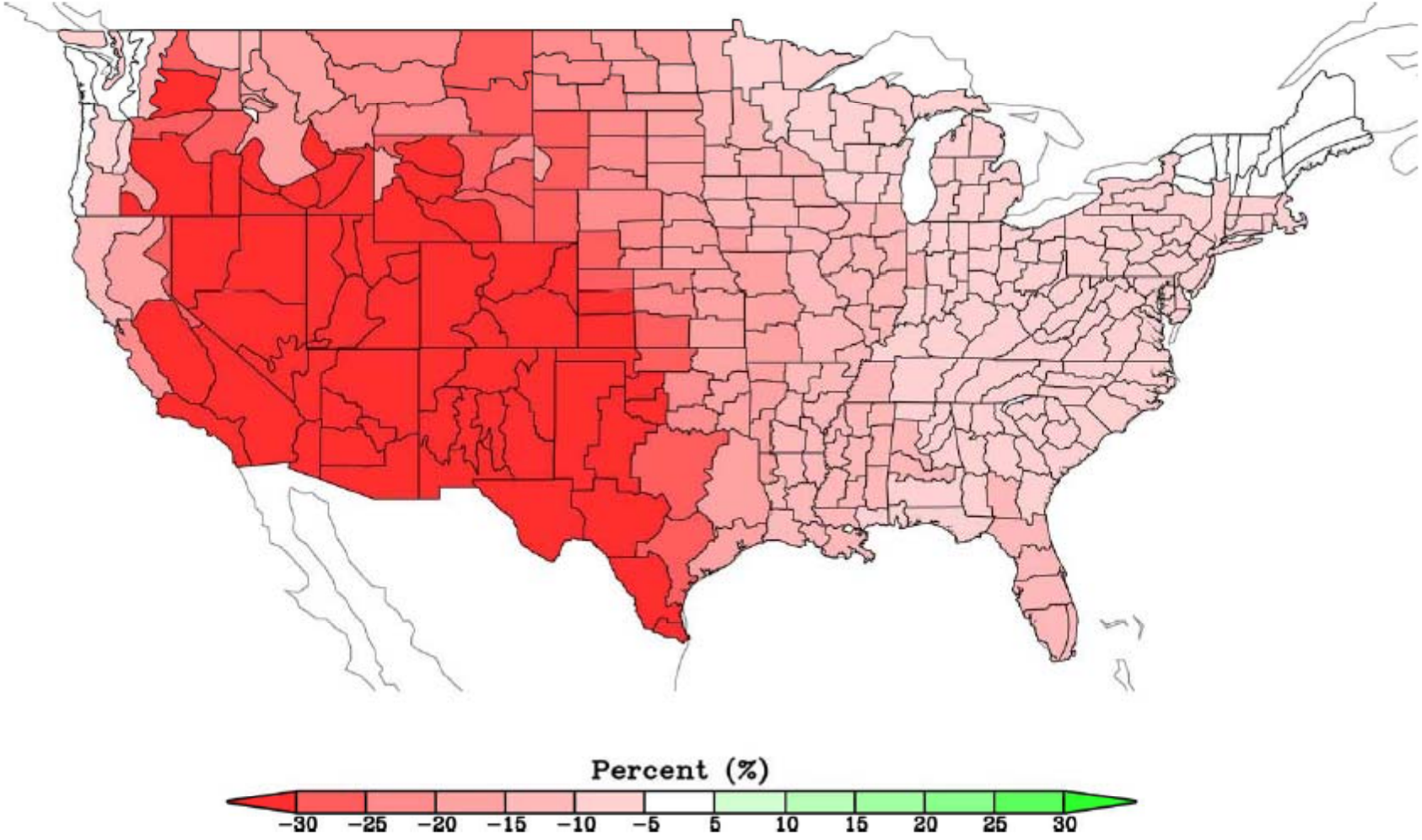
Source: EPRI 2003

Change in Annual Temperature
2035-2060



Source: NOAA

Change in Annual (PCPN-Potential Evapotranspiration) 2035-2060



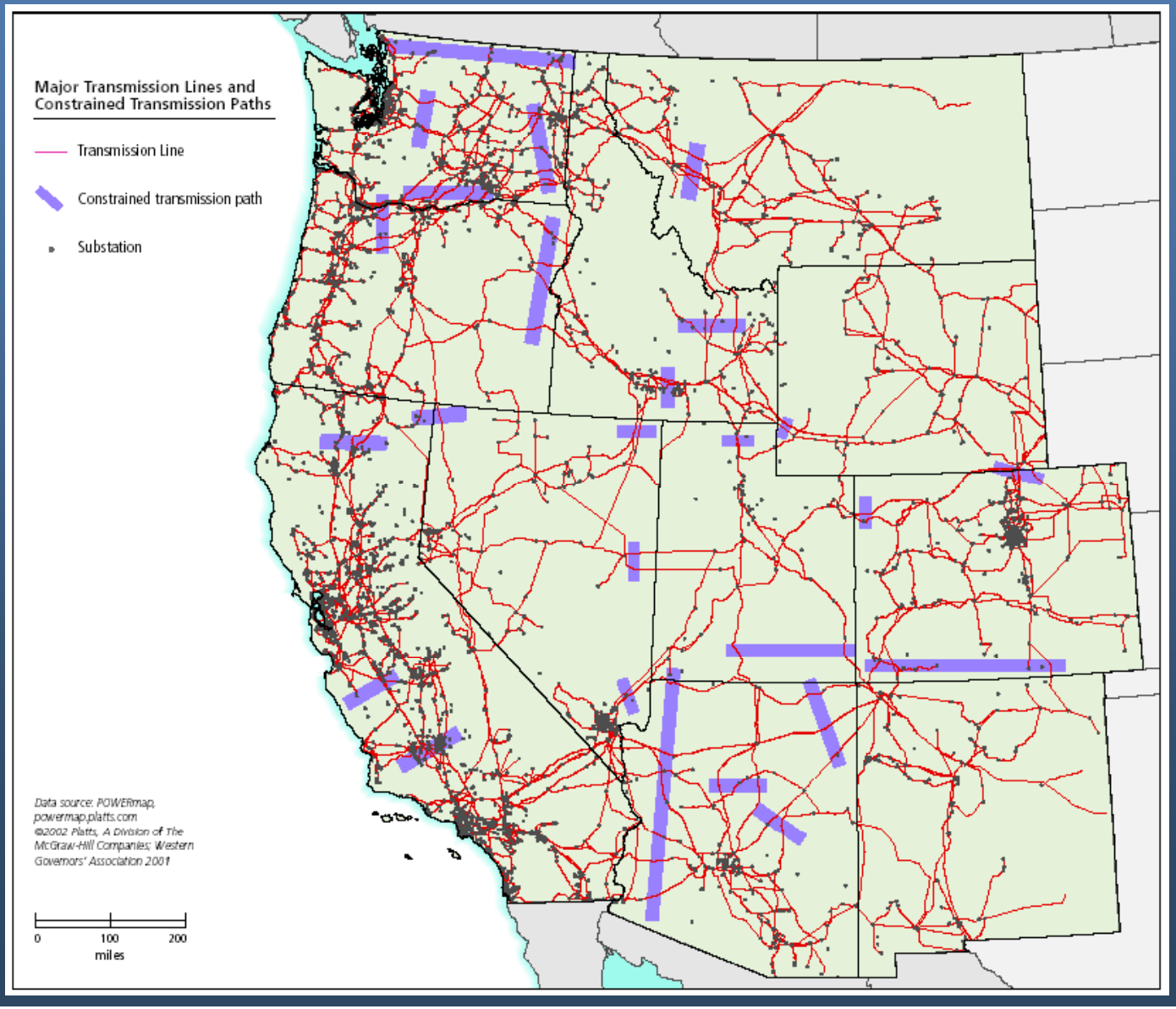
Source: NOAA

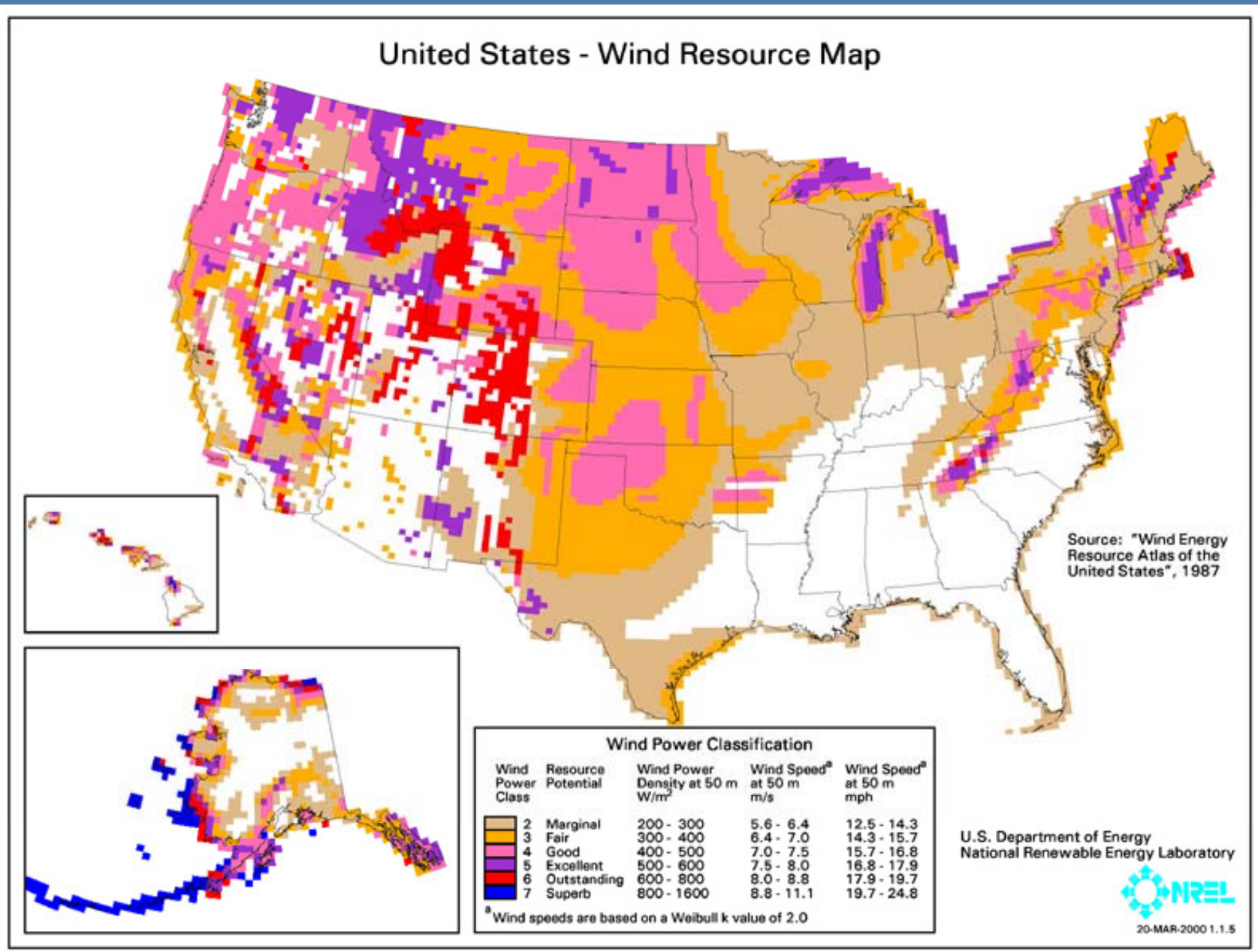
Energy-Water Nexus

Key Issues for Wind Power

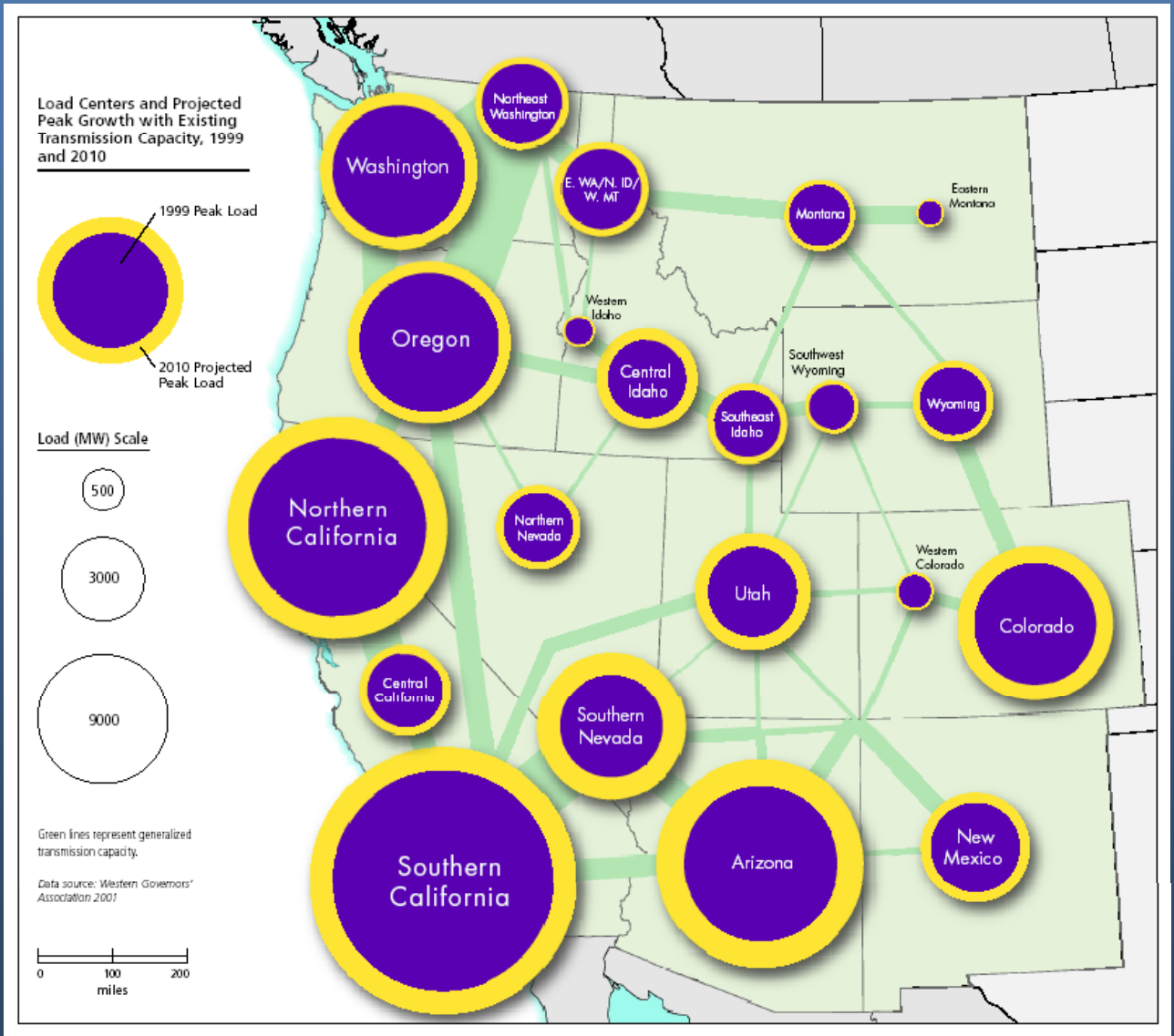
- Policy Uncertainty
- Siting and Permitting: avian, noise, visual, federal land
- Transmission: FERC rules, access, new lines
- Operational impacts: intermittency, ancillary services, allocation of costs
- Accounting for non-monetary value: green power, no fuel price risk, reduced emissions

Transmission Growth

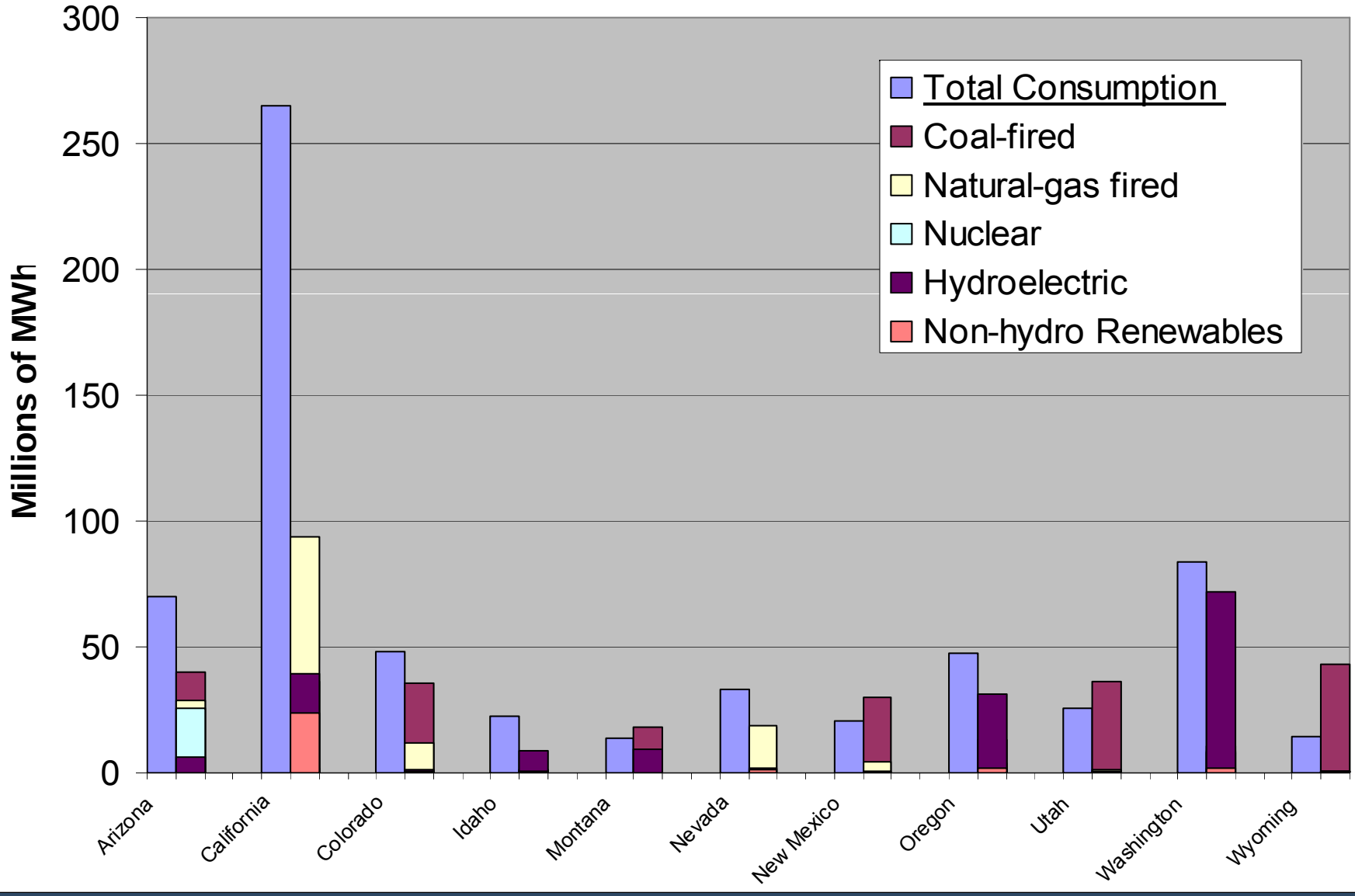



United States - Wind Resource Map
Source: "Wind Energy Resource Atlas of the United States", 1987
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m²
Wind Speed[a] at 50 m m/s
Wind Speed[a] at 50 m mph
2 Marginal 200 - 300 5.6 - 6.4 12.5 - 14.3
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb 800 - 1600 8.8 - 11.1 19.7 - 24.8
[a] Wind speeds are based on a Weibull k value of 2.0
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
20-MAR-2000 1.1.5

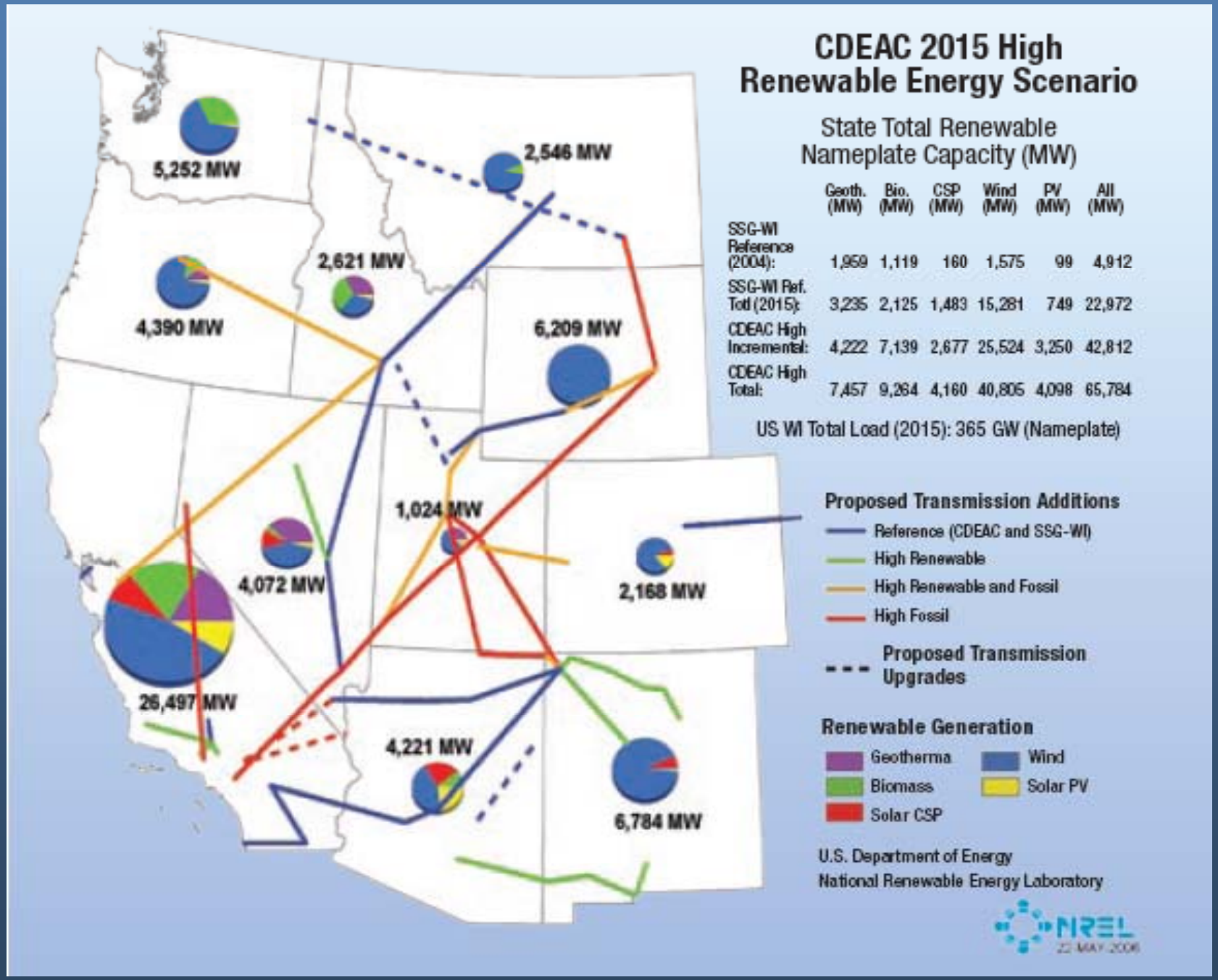
Load Growth


Load Centers and Projected Peak Growth with Existing Transmission Capacity, 1999 and 2010
1999 Peak Load
2010 Projected Peak Load
Load (MW) Scale
500
3000
9000
Green lines represent generalized transmission capacity.
Data source: Western Governors' Association 2001
0
100
200
miles
Northeast Washington
Washington
E. WA/N. ID/ W. MT
Montana
Eastern Montana
Western Idaho
Oregon
Central Idaho
Southwest Wyoming
Southeast Idaho
Wyoming
Northern California
Northern Nevada
Western Colorado
Utah
Colorado
Central California
Southern Nevada
Southern California
Arizona
New Mexico

Electricity Generation and Consumption in the West



Source: EIA, 2005 data


CDEAC 2015 High Renewable Energy Scenario
State Total Renewable Nameplate Capacity (MW)
Geoth. (MW) Bio. (MW) CSP (MW) Wind (MW) PV (MW) All (MW)
SSG-WI Reference (2004): 1,959 1,119 160 1,575 99 4,912
SSG-WI Ref. Totl (2015): 3,235 2,125 1,483 15,281 749 22,972
CDEAC High Incremental: 4,222 7,139 2,677 25,524 3,250 42,812
CDEAC High Total: 7,457 9,264 4,160 40,805 4,098 65,784
US WI Total Load (2015): 365 GW (Nameplate)
5,252 MW
2,546 MW
2,621 MW
4,390 MW
6,209 MW
1,024 MW
4,072 MW
2,168 MW
26,497 MW
4,221 MW
6,784 MW
Proposed Transmission Additions
Reference (CDEAC and SSG-WI)
High Renewable
High Renewable and Fossil
High Fossil
Proposed Transmission Upgrades
Renewable Generation
Geotherma
Biomass
Solar CSP
Wind
Solar PV
U.S. Department of Energy
National Renewable Energy Laboratory
NREL

Integrating Wind into Power Systems

Table 6. Key Results from Major Wind Integration Studies Completed 2003-2006

Date	Study	Wind Capacity Penetration	Cost ($/MWh)				
			Regulation	Load Following	Unit Commitment	Gas Supply	TOTAL
2003	Xcel-UWIG	3.5%	0	0.41	1.44	na	1.85
2003	We Energies	4%	1.12	0.09	0.69	na	1.90
2003	We Energies	29%	1.02	0.15	1.75	na	2.92
2004	Xcel-MNDOC	15%	0.23	na	4.37	na	4.60
2005	PacifiCorp	20%	0	1.6	3	na	4.60
2006	CA RPS (multi-year)	4%	0.45*	trace	na	na	0.45
2006	Xcel-PSCo	10%	0.2	na	2.26	1.26	3.72
2006	Xcel-PSCo	15%	0.2	na	3.32	1.45	4.97
2006	MN-MISO 20%	31%	na	na	na	na	4.41**

** 3-year average* *** highest over 3-year evaluation period*

Source: National Renewable Energy Laboratory.

"The future ain't what it used to be."

- Yogi Berra

A New Vision
For Wind Energy in the U.S.

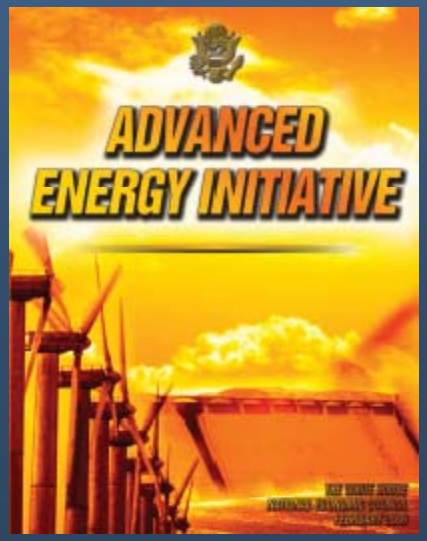

White House photo by Eric Draper

State of the Union Address

"…We will invest more in … **revolutionary** and…**wind technologies**"

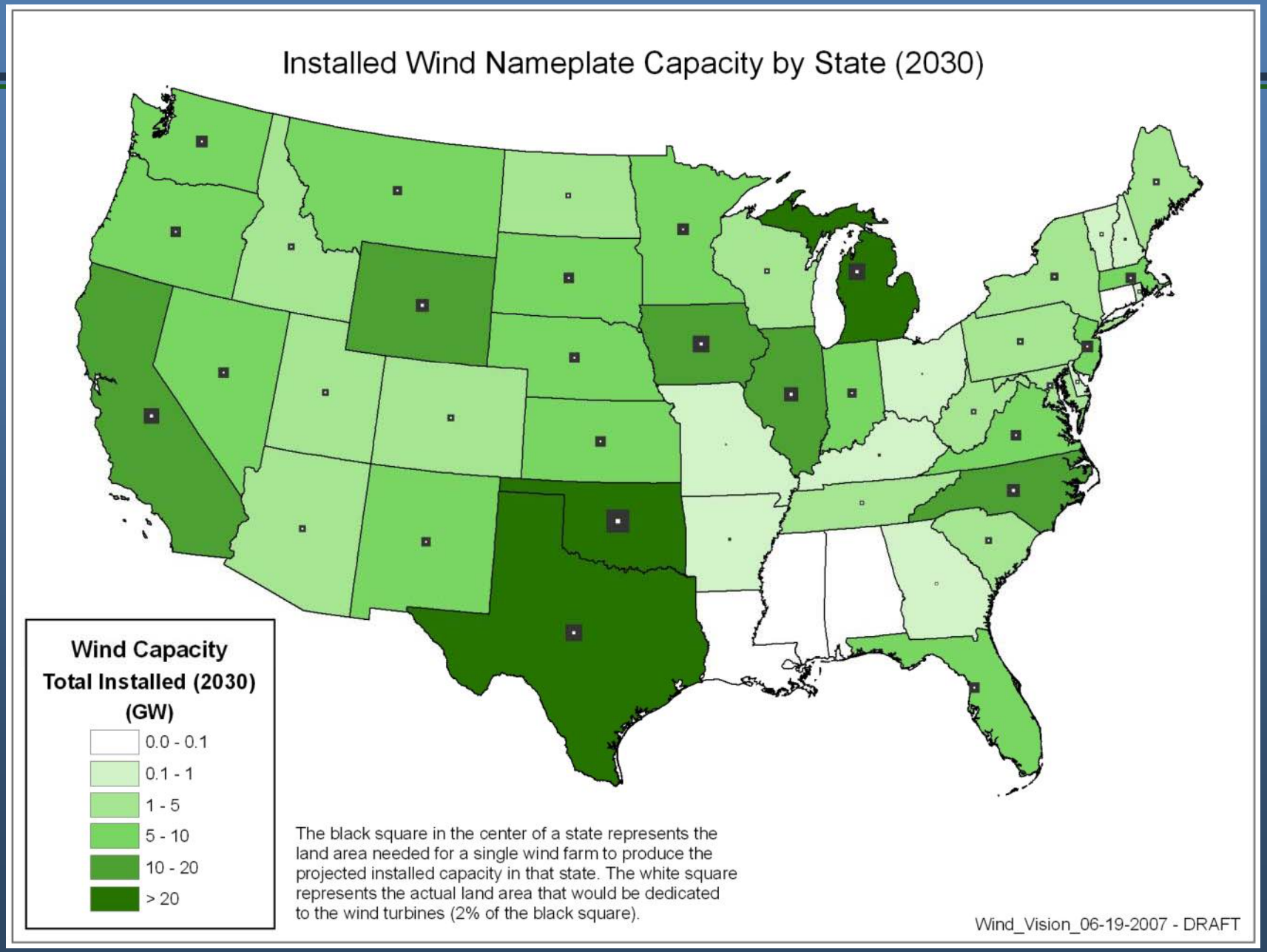
Advanced Energy Initiative

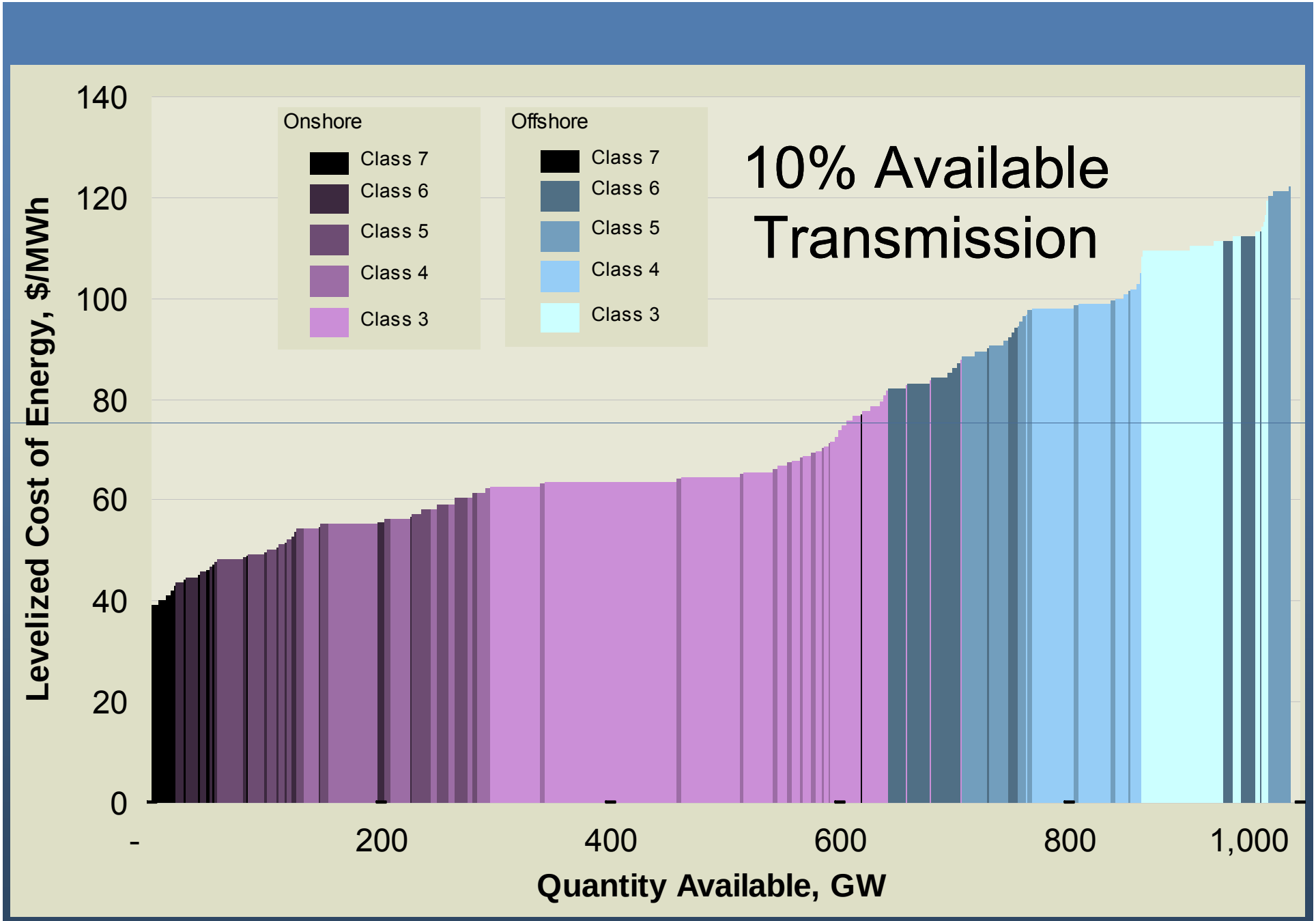
"Areas with good wind resources have the potential to **supply up to 20% of the electricity** consumption of the United States."



20% Wind-Electricity Vision

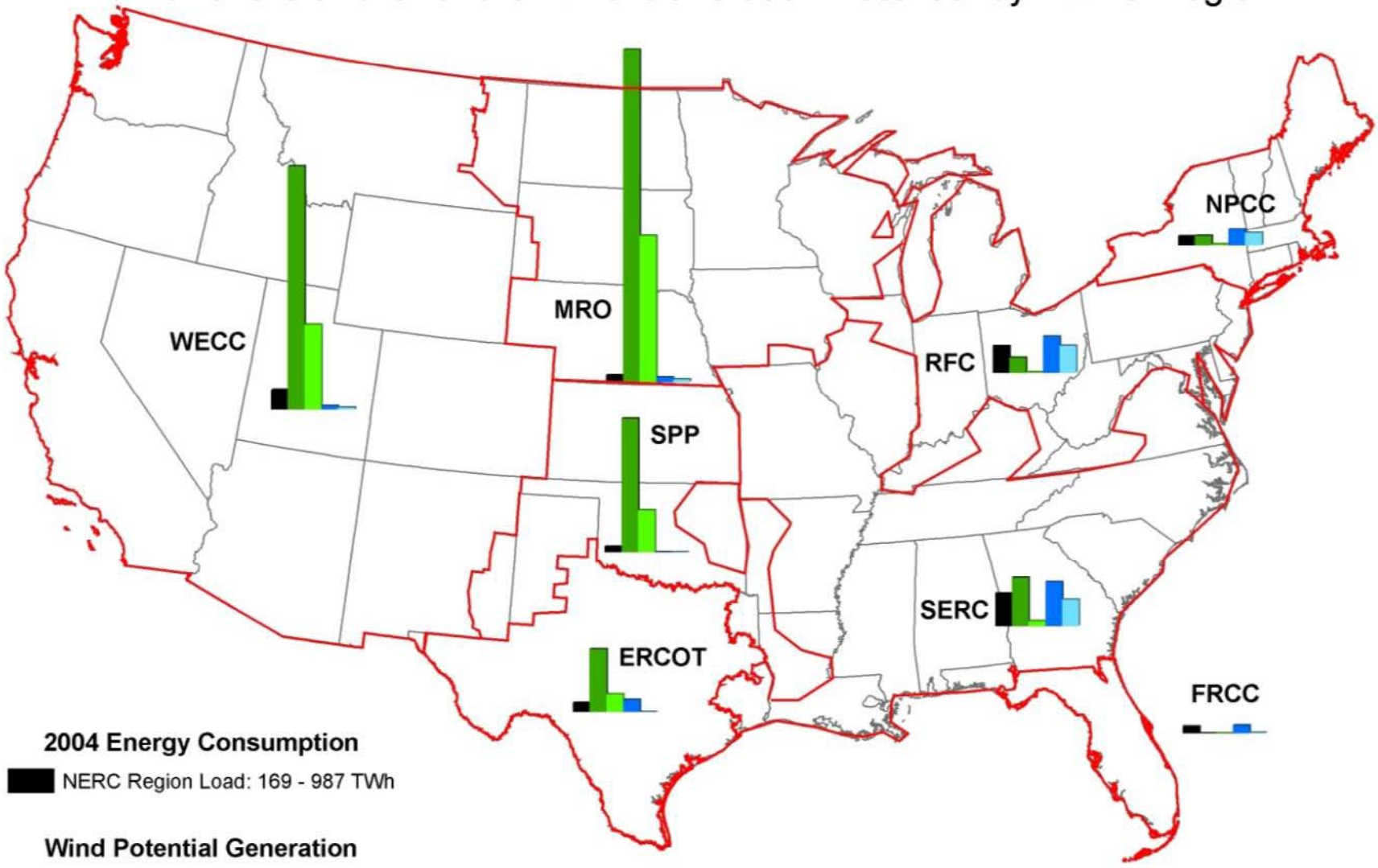
Wind energy will provide 20% of U.S. electricity needs by 2030, securing America's leadership in reliable, clean energy technology. As an inexhaustible and affordable domestic resource, wind strengthens our energy security, improves the quality of the air we breathe, slows climate change, and revitalizes rural communities.


Installed Wind Nameplate Capacity by State (2030)
Wind Capacity
Total Installed (2030)
(GW)
0.0 - 0.1
0.1 - 1
1 - 5
5 - 10
10 - 20
> 20
The black square in the center of a state represents the land area needed for a single wind farm to produce the projected installed capacity in that state. The white square represents the actual land area that would be dedicated to the wind turbines (2% of the black square).
Wind_Vision_06-19-2007 - DRAFT



2010 Costs w/ PTC, $1,600/MW-mile, w/o Integration costs

Onshore and Offshore Wind Generation Potential by NERC Region



2004 Energy Consumption

NERC Region Load: 169 - 987 TWh

Wind Potential Generation

Onshore, Class 3 and greater: 0 - 10,013 TWh

Onshore, Class 4 and greater: 0 - 4,390 TWh

Offshore, Class 4 and greater: 0 - 1,325 TWh

Offshore, Class 5 and greater: 0 - 803 TWh

Exclusions were applied to the onshore wind resource areas. Offshore resource was limited to shallow areas (<30 m) within 50 nm of shore.

U.S. Department of Energy
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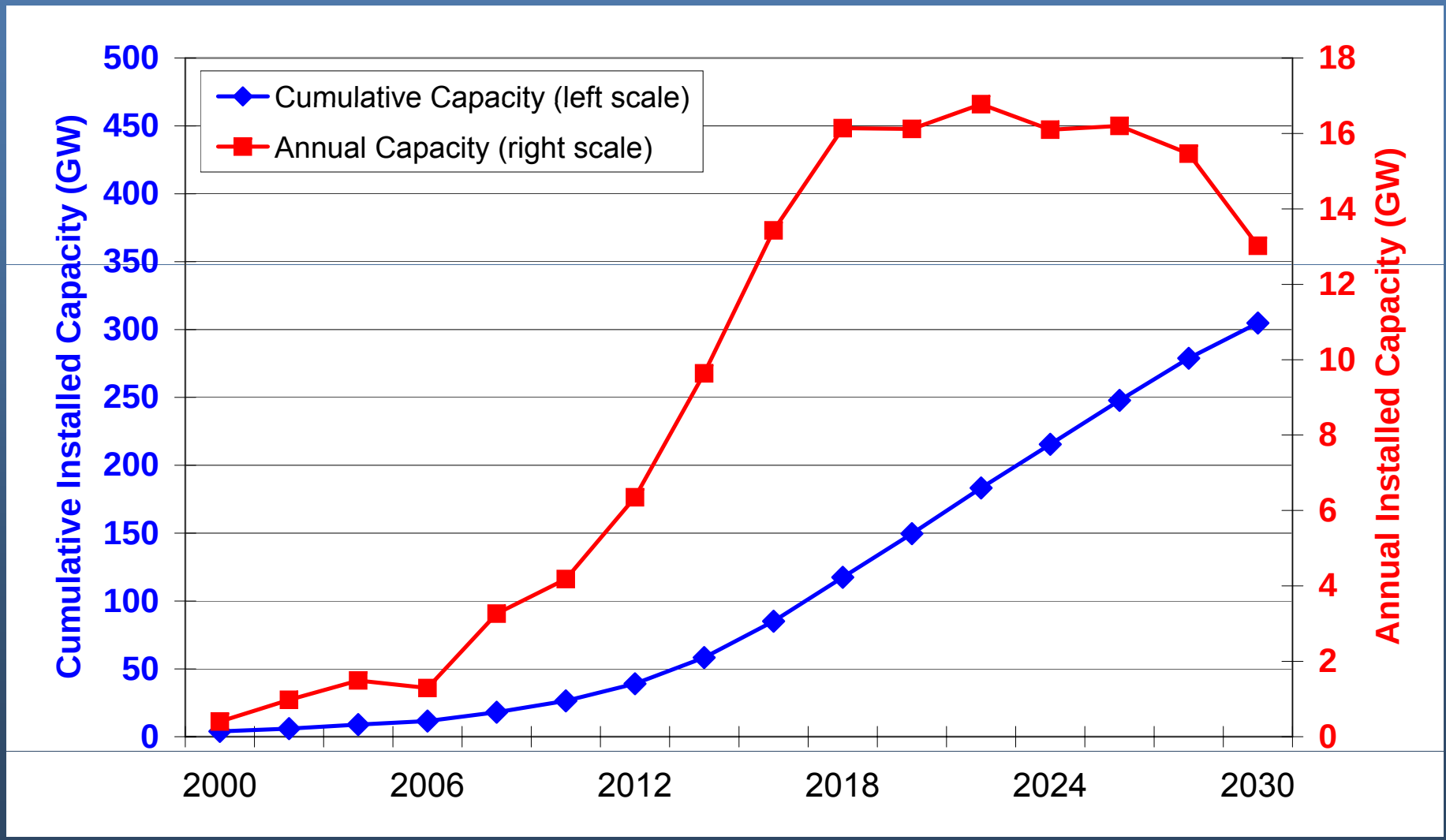
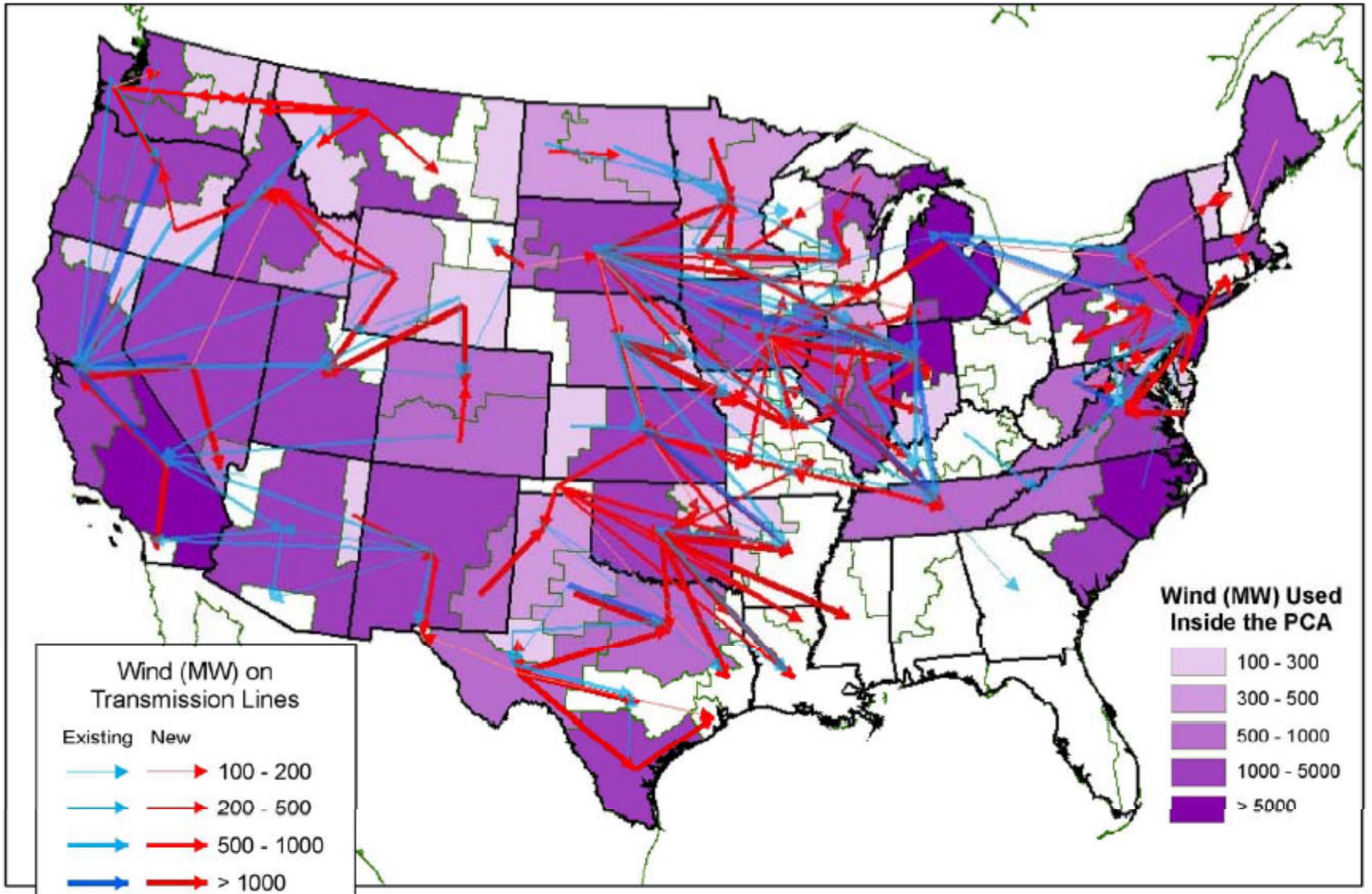
What does 20% Wind look like?



Source: AWEA 20% Vision

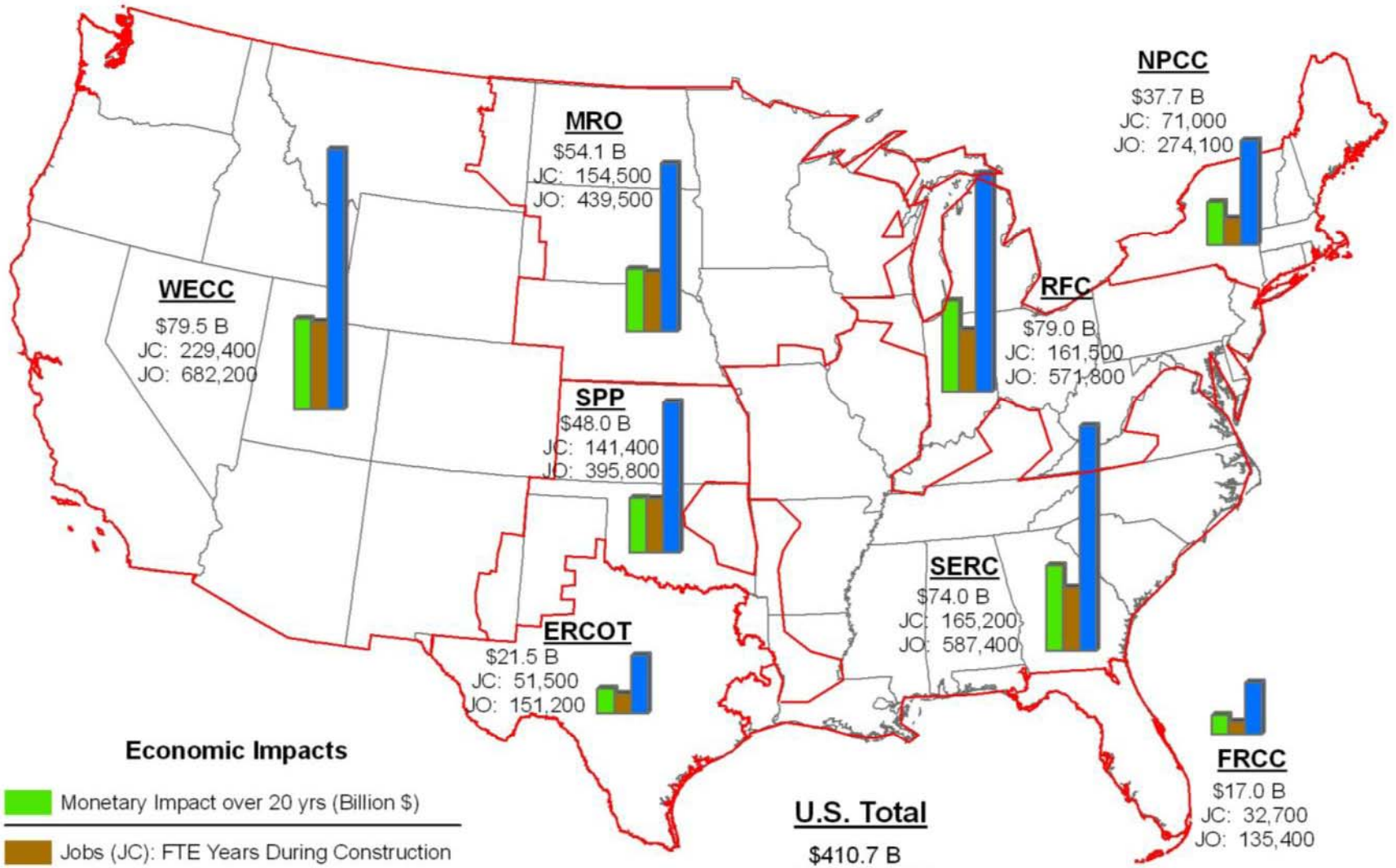
2030 - Between PCA Transfers and In-PCA Use for Wind (All Classes)

Total Between PCA Transfer >= 100 MW (all power classes, onshore and offshore)
Arrows originate and terminate at the centroid of the PCA for visualization purposes; they do not represent physical locations of transmission lines



Optimistic_Case_05-15-2007 - DRAFT

20% Wind Electricity by 2030 - Economic Impacts by NERC Region



Economic Impacts

Monetary Impact over 20 yrs (Billion $)

Jobs (JC): FTE Years During Construction

Jobs (JO): FTE Years over 20 yrs Operation

Wind Vision case = 304 GW of wind capacity.
All job values rounded to the nearest 100.

U.S. Total

$410.7 B
JC: 1,007,200
JO: 3,237,400

U.S. Department of Energy
National Renewable Energy Laboratory

NREL

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Colorado – Economic Impacts

From the 20% Scenario
2,507 MW new development

Wind energy's economic "ripple effect"

Direct Impacts

Payments to Landowners:
- $7 Million/yr

Local Property Tax Revenue:
- $30 Million/yr

Construction Phase:
- 3,500 new jobs
- $475 M to local economies

Operational Phase:
- 600 new long-term jobs
- $55 M/yr to local economies

Indirect & Induced Impacts

Construction Phase:
- 3,100 new jobs
- $325 M to local economies

Operational Phase:
- 500 local jobs
- $50 M/yr to local economies

Totals (construction + 20yrs)

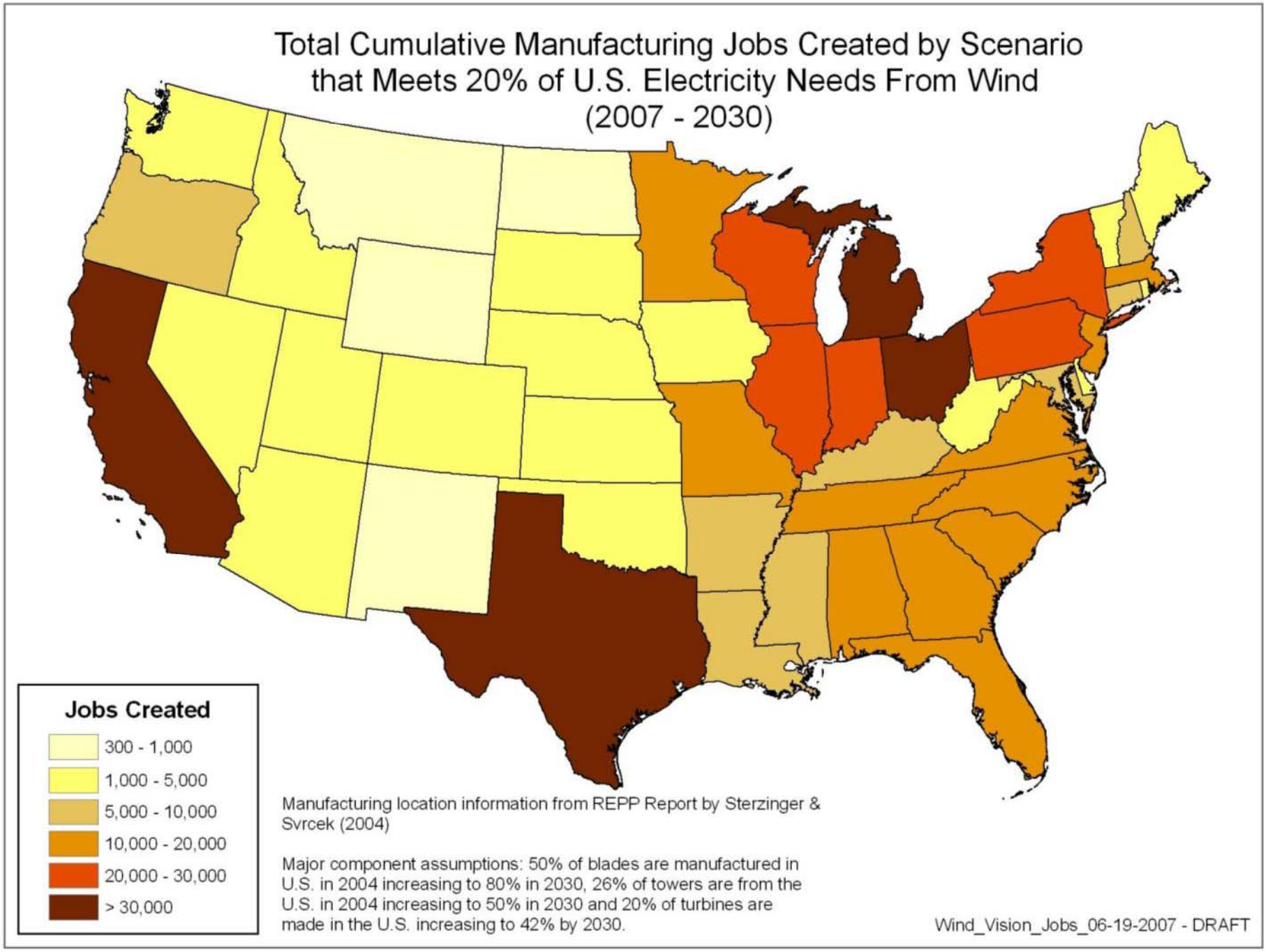
Total economic benefit = $2.9 B

New local jobs during construction = 6,600

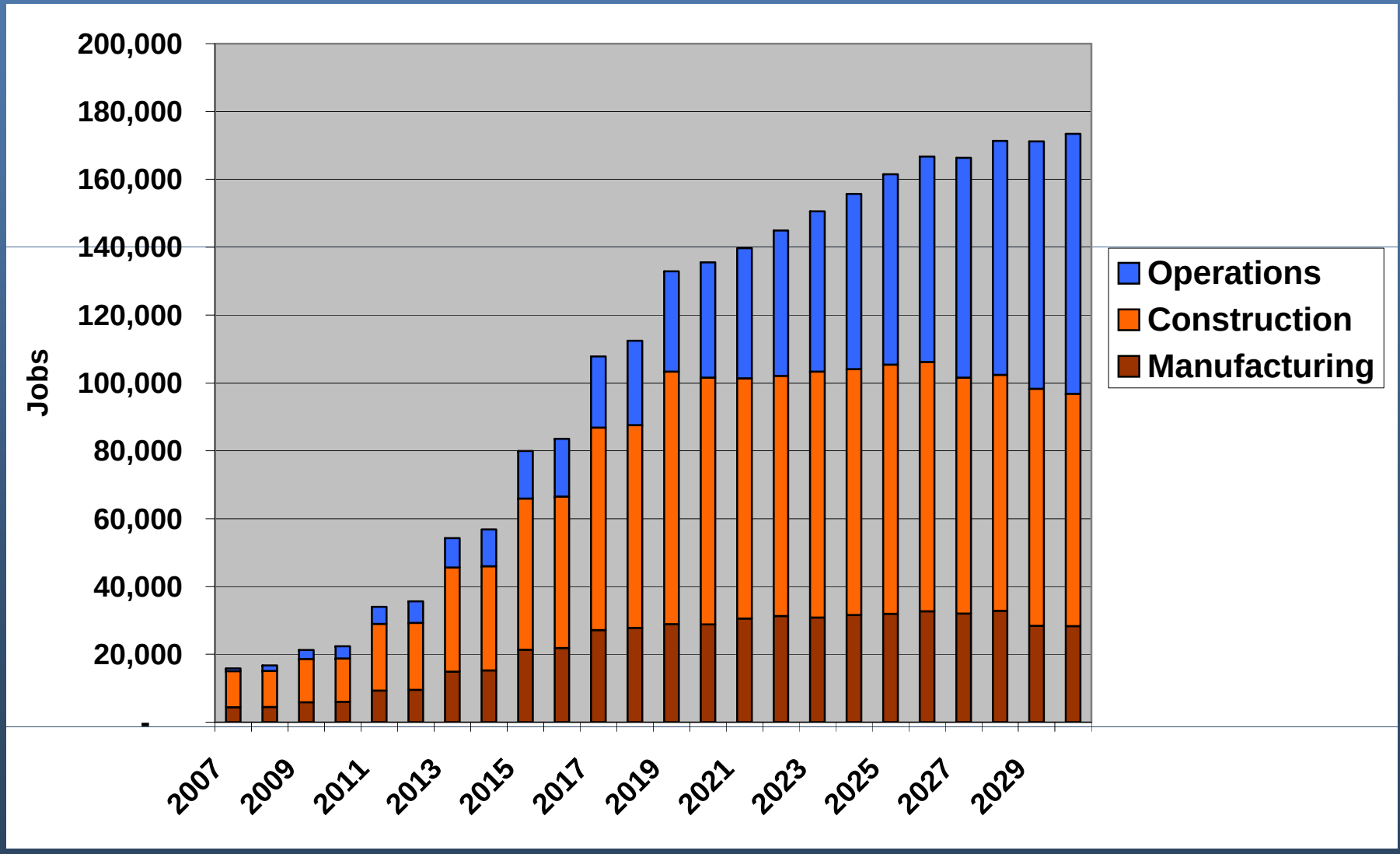
New local long-term jobs = 1,000

All jobs rounded to the nearest hundred jobs; Millions of dollars greater than 10 million are rounded to the nearest five million

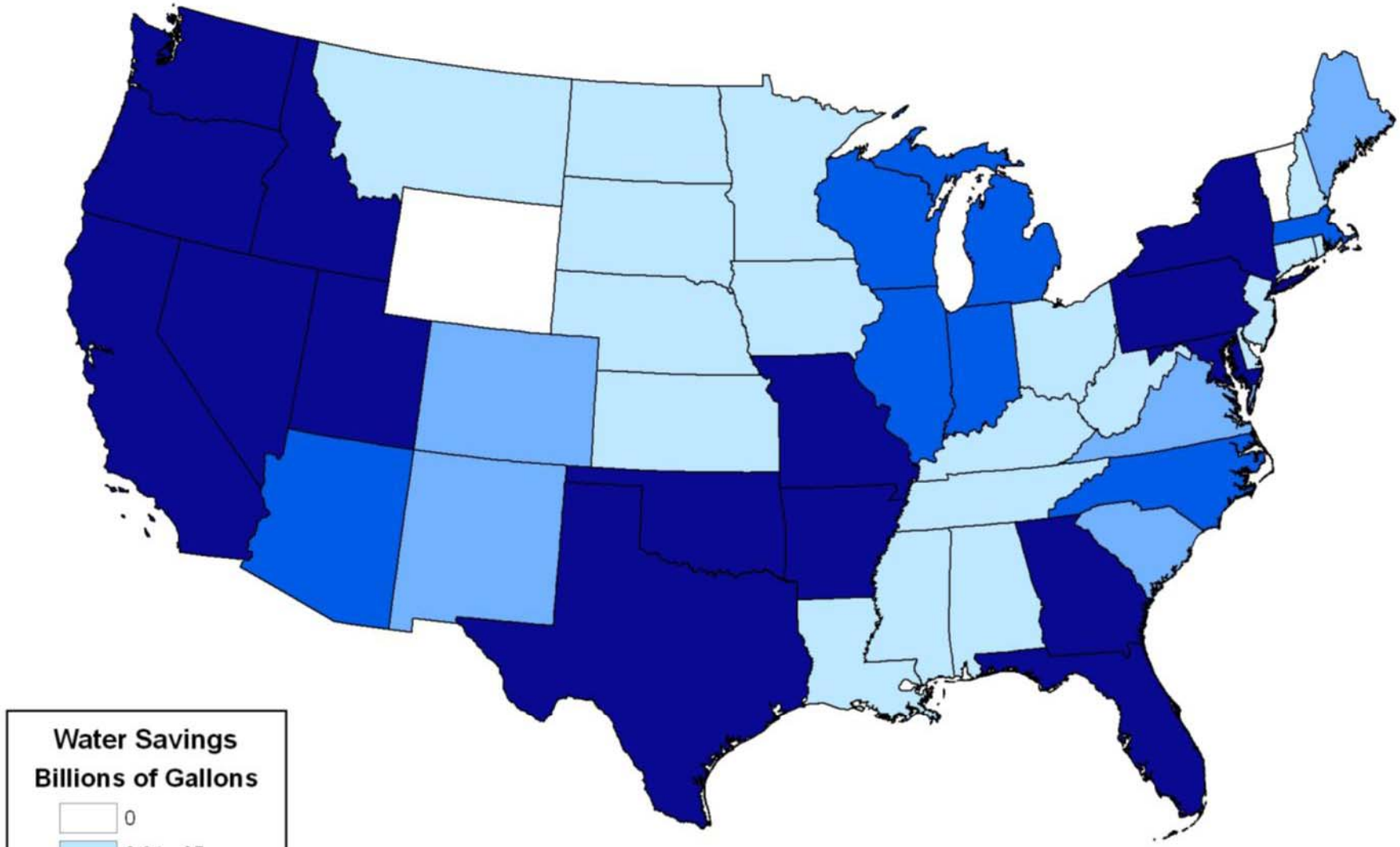
Construction Phase = 1-2 years
Operational Phase = 20+ years


Total Cumulative Manufacturing Jobs Created by Scenario
that Meets 20% of U.S. Electricity Needs From Wind
(2007 - 2030)
Jobs Created
300 - 1,000
1,000 - 5,000
5,000 - 10,000
10,000 - 20,000
20,000 - 30,000
> 30,000
Manufacturing location information from REPP Report by Sterzinger & Svrcek (2004)
Major component assumptions: 50% of blades are manufactured in U.S. in 2004 increasing to 80% in 2030, 26% of towers are from the U.S. in 2004 increasing to 50% in 2030 and 20% of turbines are made in the U.S. increasing to 42% by 2030.
Wind_Vision_Jobs_06-19-2007 - DRAFT

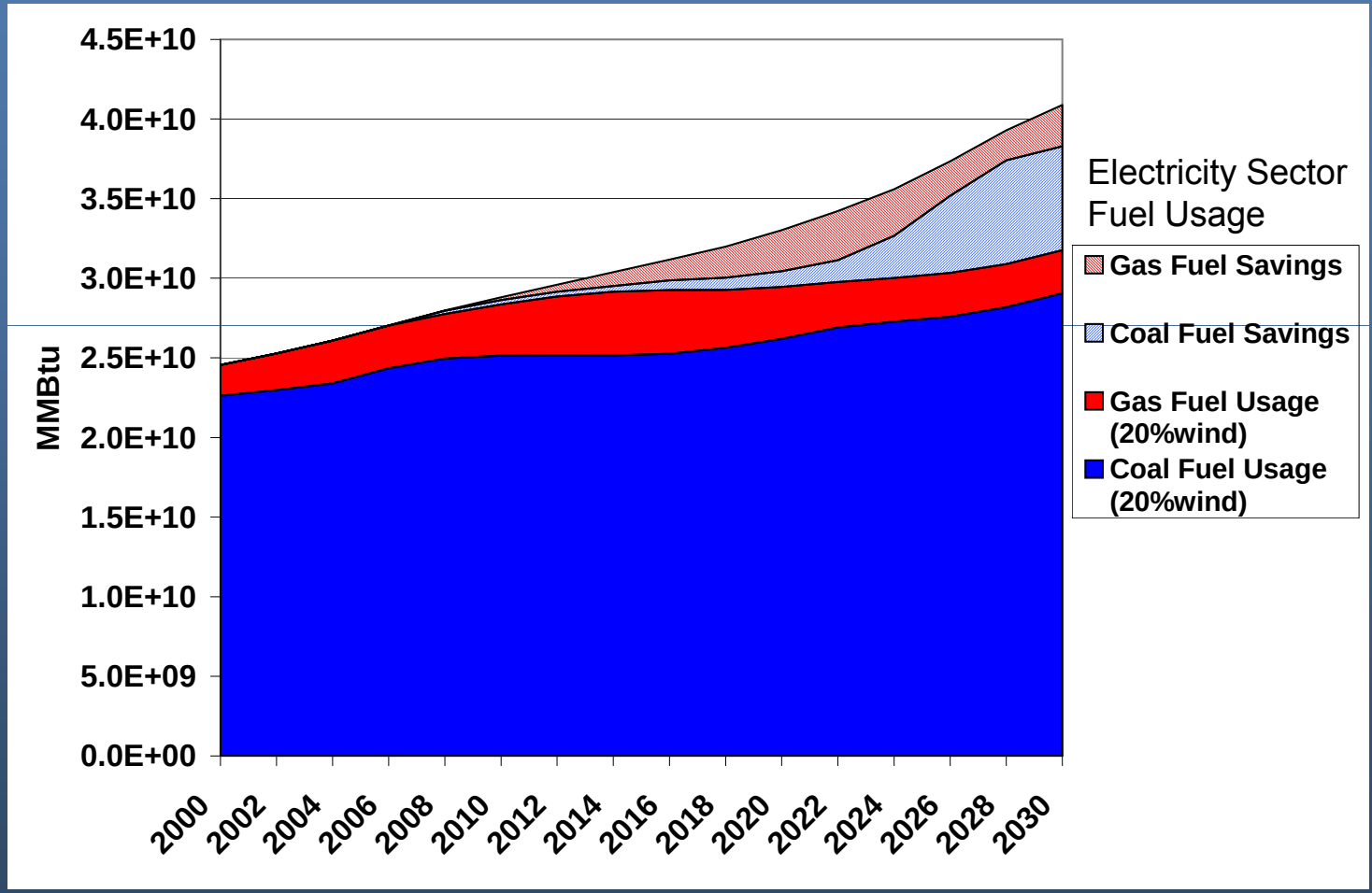
20% Wind Vision Employment



Cumulative Water Savings Due to Deployment of Wind Energy (2008 - 2030)

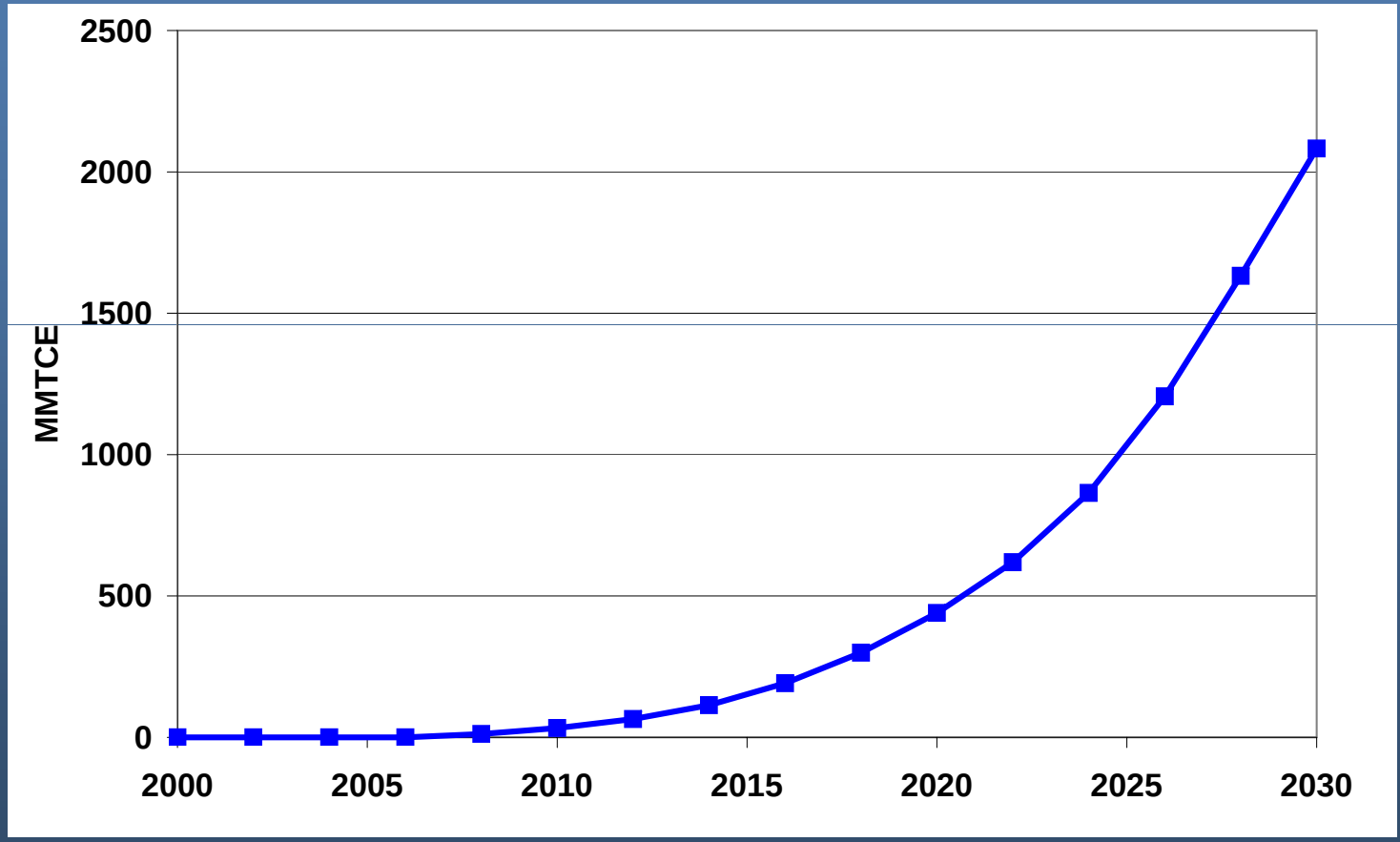


Fuel Savings From Wind



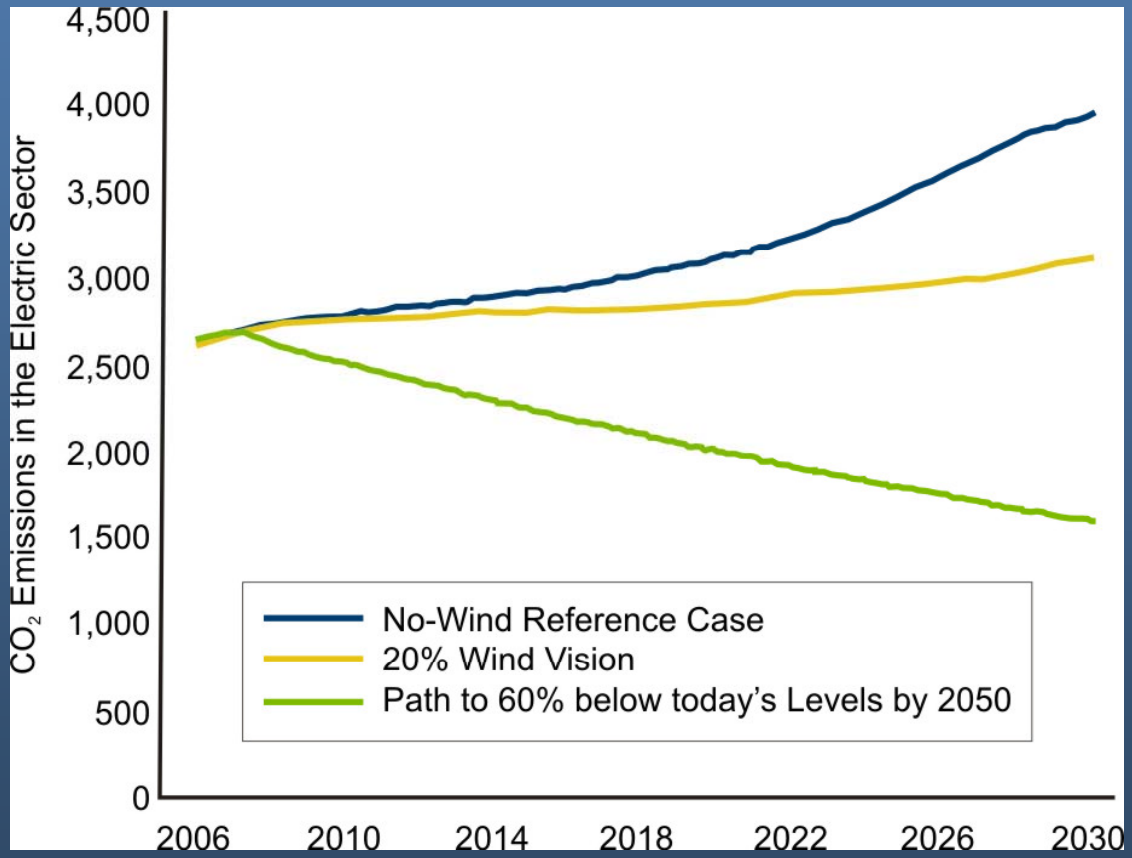
Reduction in National Gas Consumption in 2030 (%)	Natural Gas Price Reduction in 2030 (2006$/MMBtu)	Present Value Benefits (billion 2006$)	Levelized Benefit of Wind ($/MWh)
11%	0.6 -**1.1**- 1.5	86 - **150** - 214	16.6 - **29** - 41.6

Cumulative Carbon Savings

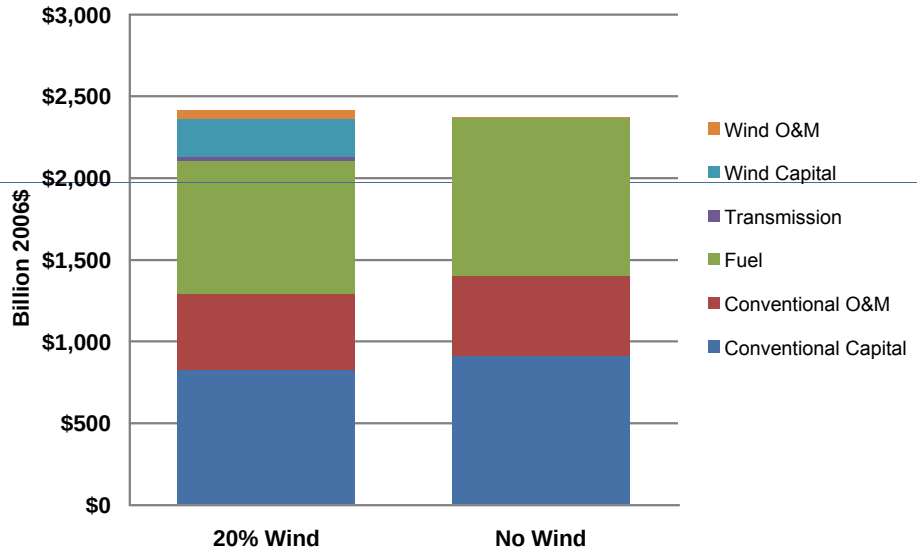


Cumulative Carbon Savings (2007-2050, MMTCE)	Present Value Benefits (billion 2006$)	Levelized Benefit of Wind ($/MWh-wind)
4,182 MMTCE	$ 50 - $145	$ 9.7/MWh - $ 28.2/MWh

Electric Sector CO_2 Emissions



Incremental Cost of 20% Wind Vision



	Present Value Direct Costs (billion 2006$)*	Average Incremental Levelized Cost of Wind ($/MWh-Wind)*	Average Incremental Levelized Rate Impact ($/MWh-Total)*	Impact on Average Household Customer ($/month)**
Vision Scenario	$43 billion	$8.6/MWh	$0.6/MWh	$0.5/month

* 7% real discount rate is used, as per OMB guidance; the time period of analysis is 2007-2050, withWinDS modeling used through 2030, and extrapolations used for 2030-2050.
** Assumes 11,000 kWh/year average consumption

Results: Costs & Benefits

Incremental direct cost to society	**$43 billion**
Reductions in emissions of greenhouse gasses and other atmospheric pollutants	825 M tons (2030) **$98 billion**
Reductions in water consumption	8% total electric 17% in 2030
Jobs created and other economic benefits	140,000 direct $450 billion total
Reductions in natural gas use and price pressure	11% **$150 billion**

Net Benefits: $205B + Water savings

"With public sentiment nothing can fail; without it, nothing can succeed."

- A. Lincoln

Conclusions

- 20% wind energy penetration is possible
- 20% penetration is not going to happen under business as usual scenario
- Policy choices will have a large impact on assessing the timing and rate of achieving a 20% goal
- Key Issues: market transformation, transmission, project diversity, technology development, policy, public acceptance
- 20% Vision report: February 2008

Source: AWEA 20% Vision

Humanity's Top Ten Problems for next 50 years

1. Energy
2. Water
3. Food
4. Environment
5. Poverty
6. Terrorism & War
7. Disease
8. Education
9. Democracy
10. Population

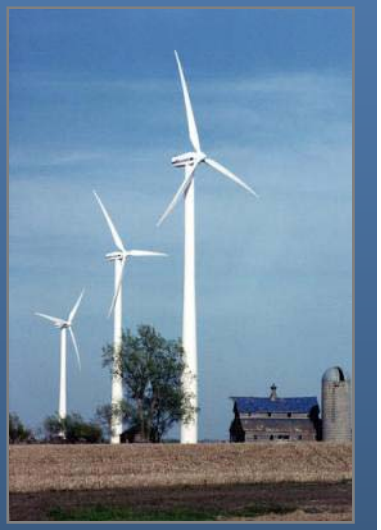
2003: 6.3 Billion people

2050: 9-10 Billion people

Source: Nobel laureate, Richard Smalley

Carpe Ventem





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