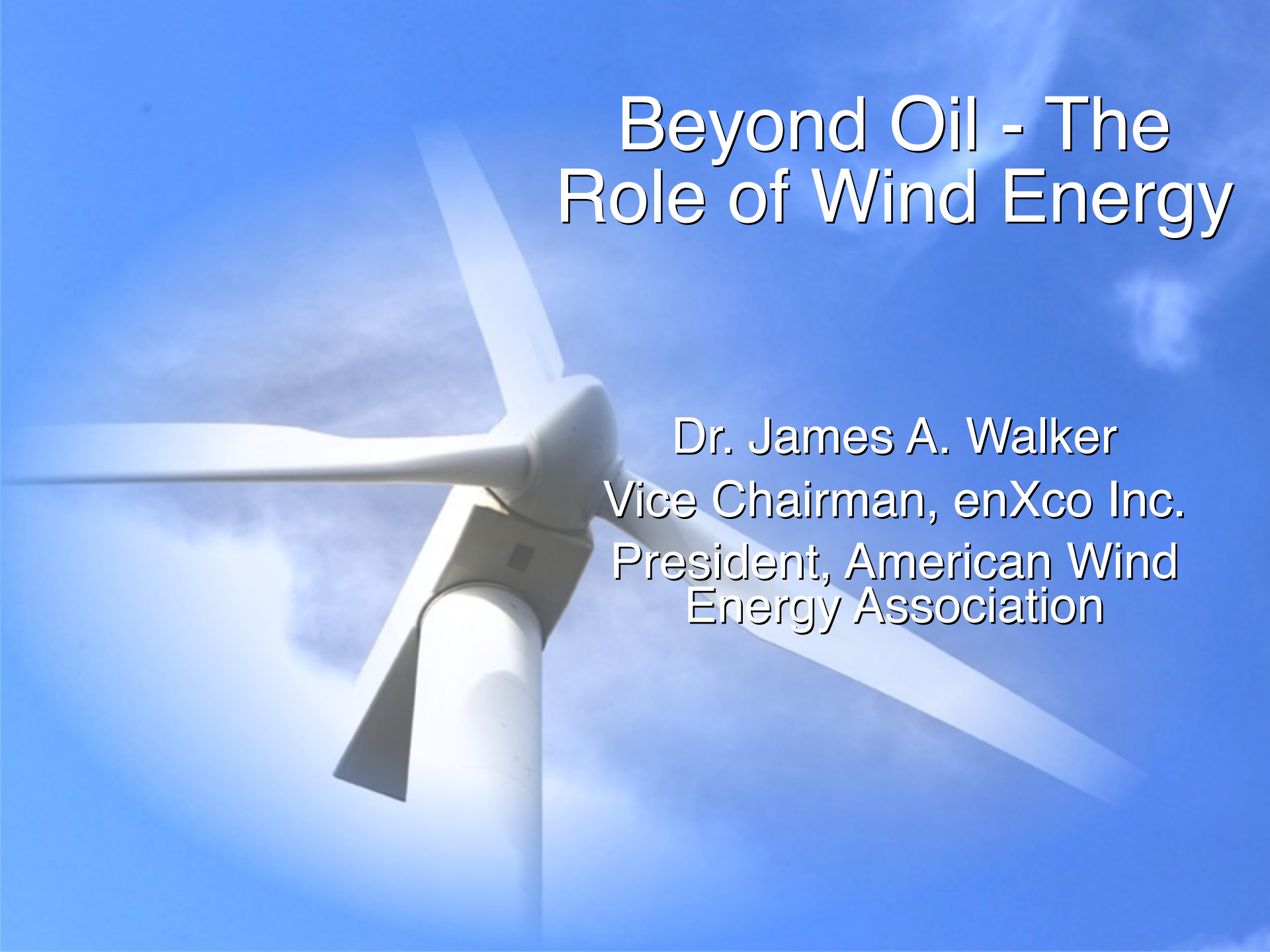
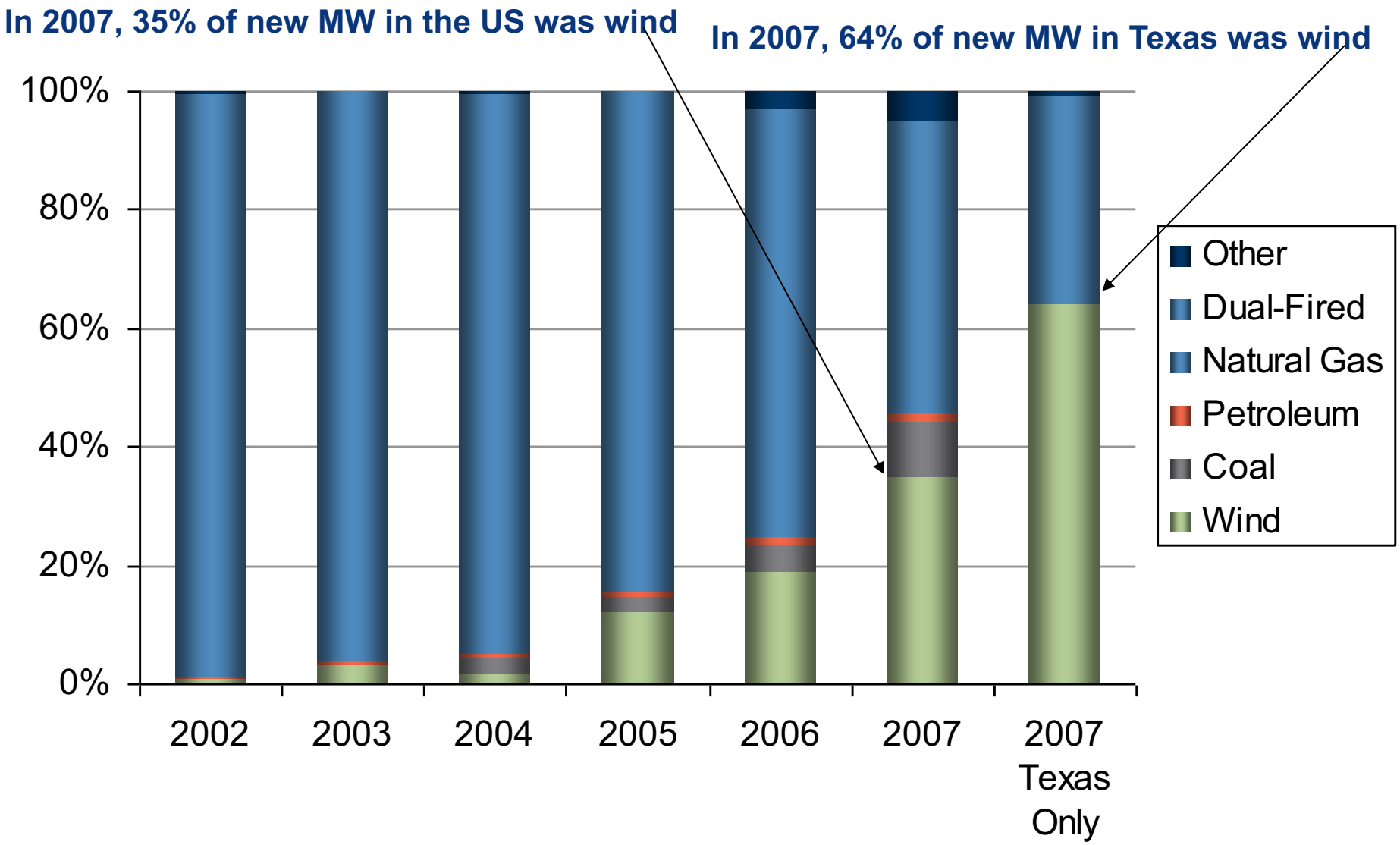


Beyond Oil - The Role of Wind Energy

Dr. James A. Walker
Vice Chairman, enXco Inc.
President, American Wind Energy Association

New Capacity Added 2002-2007 by Energy Source for the U.S. & (for 2007) Texas



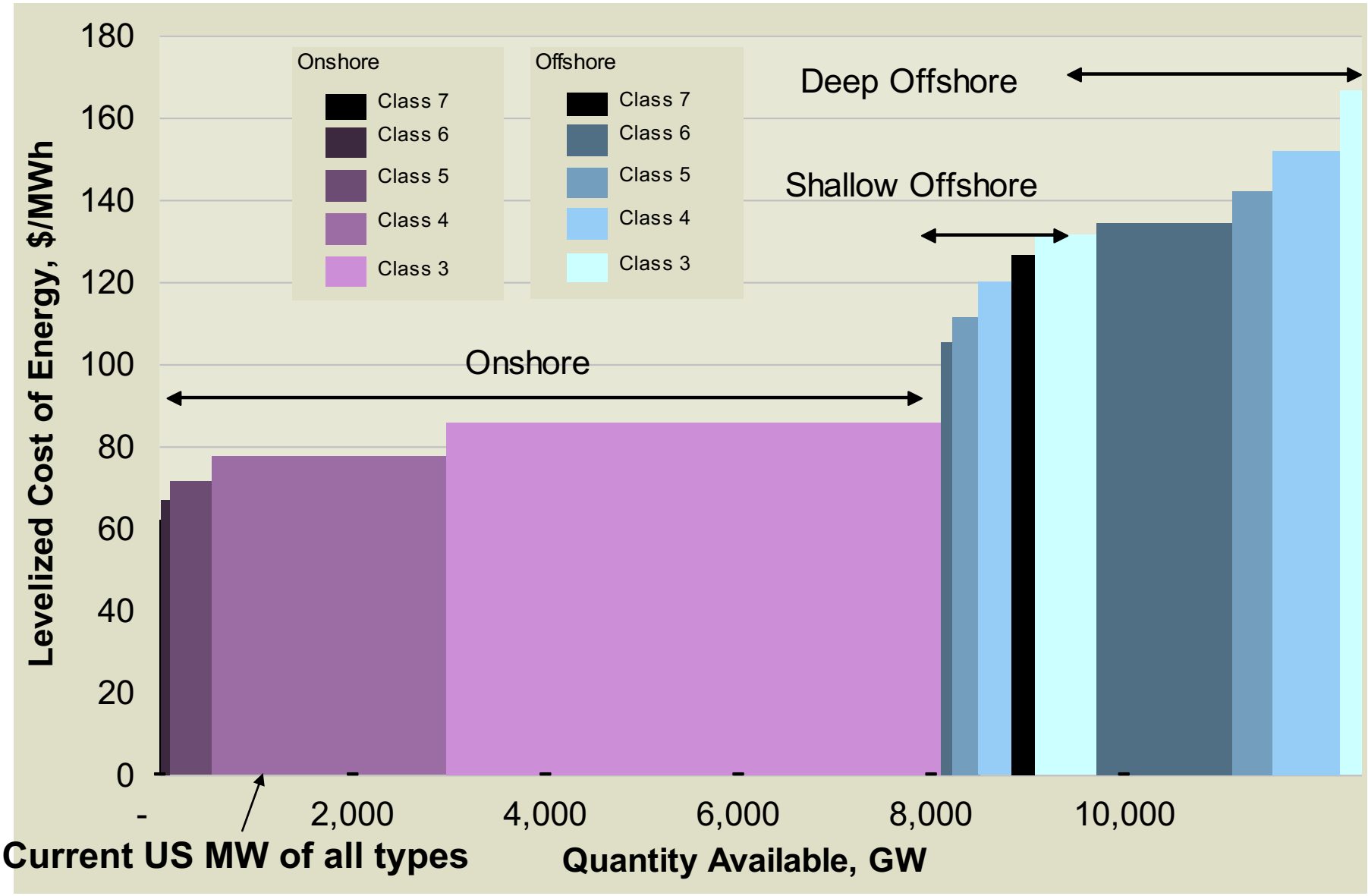
The 20% Wind Report

- Released by US DOE in May 2008
- Available at: www.20percentwind.org
- Explores one scenario for reaching 20% wind energy by 2030 and contrasts it to a scenario in which no new U.S. wind power capacity is installed
- Is not a prediction, but an analysis based on one scenario
- Does not assume specific policy support for wind (but does assume some form of stable federal support for renewables)
- Is the work of more than 100 individuals involved from 2006 - 2008 (government, industry, utilities, NGOs)
- Analyzes wind's potential contributions to energy security, economic prosperity and environmental sustainability

The 20% Wind Energy Scenario

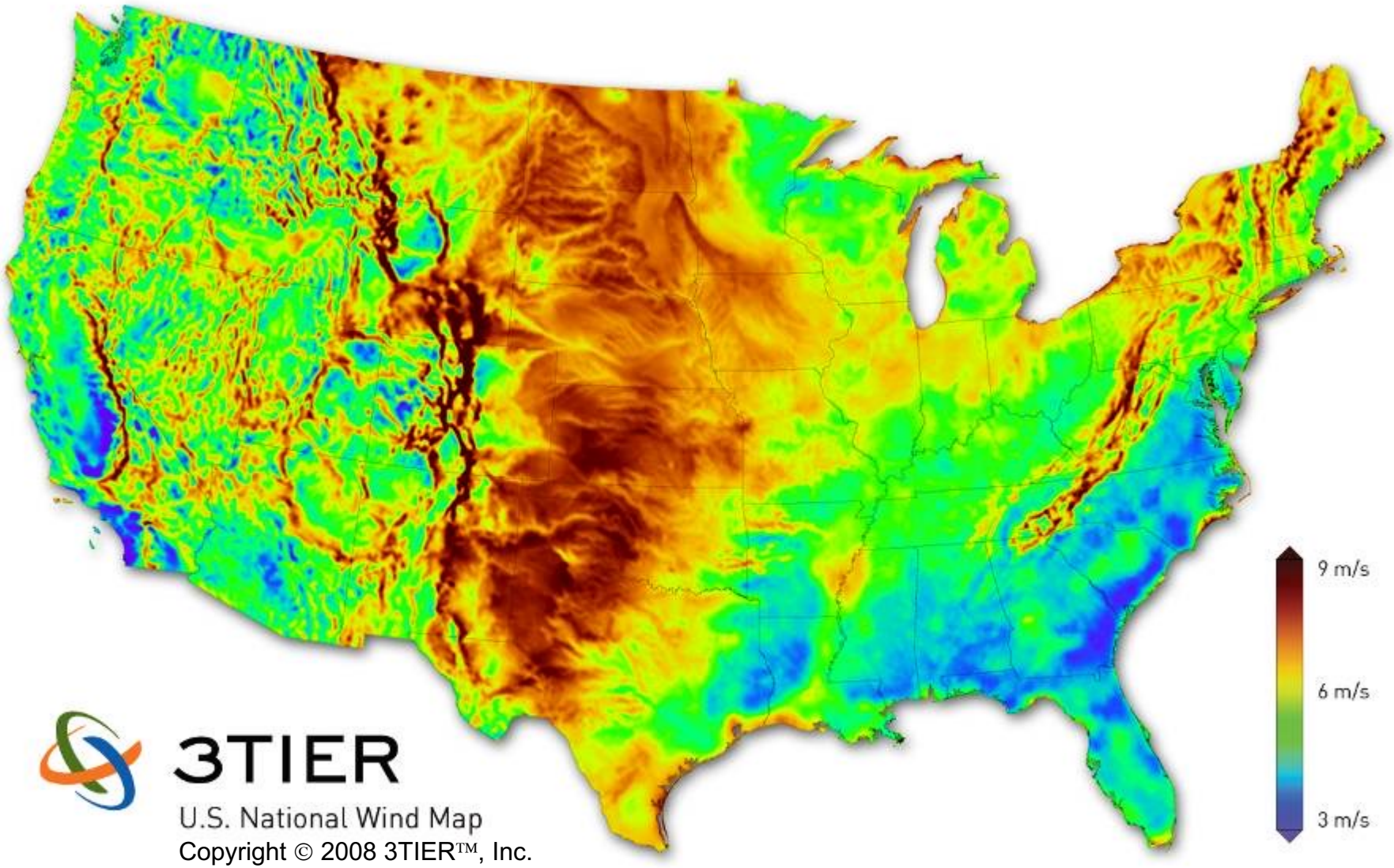
- Primary Assumptions:
  - U.S. electricity consumption grows 39% from 2005 to 2030 -- to 5.8 billion MWh (Source: EIA)
  - Wind turbine energy production increases about 15% by 2030
  - Wind turbine costs decrease about 10% by 2030
  - No major breakthroughs in wind technology
- Primary Findings:
  - 20% wind electricity would require about 300 GW (300,000 MW) of wind generation
  - Affordable, accessible wind resources are available across the nation
  - Cost to integrate wind is modest if properly planned
  - Raw materials are available
  - Transmission a challenge

Resource Potential Exceeds Total US Electricity Demand



2010 Costs w/o PTC after 2008, w/o Transmission or Integration costs

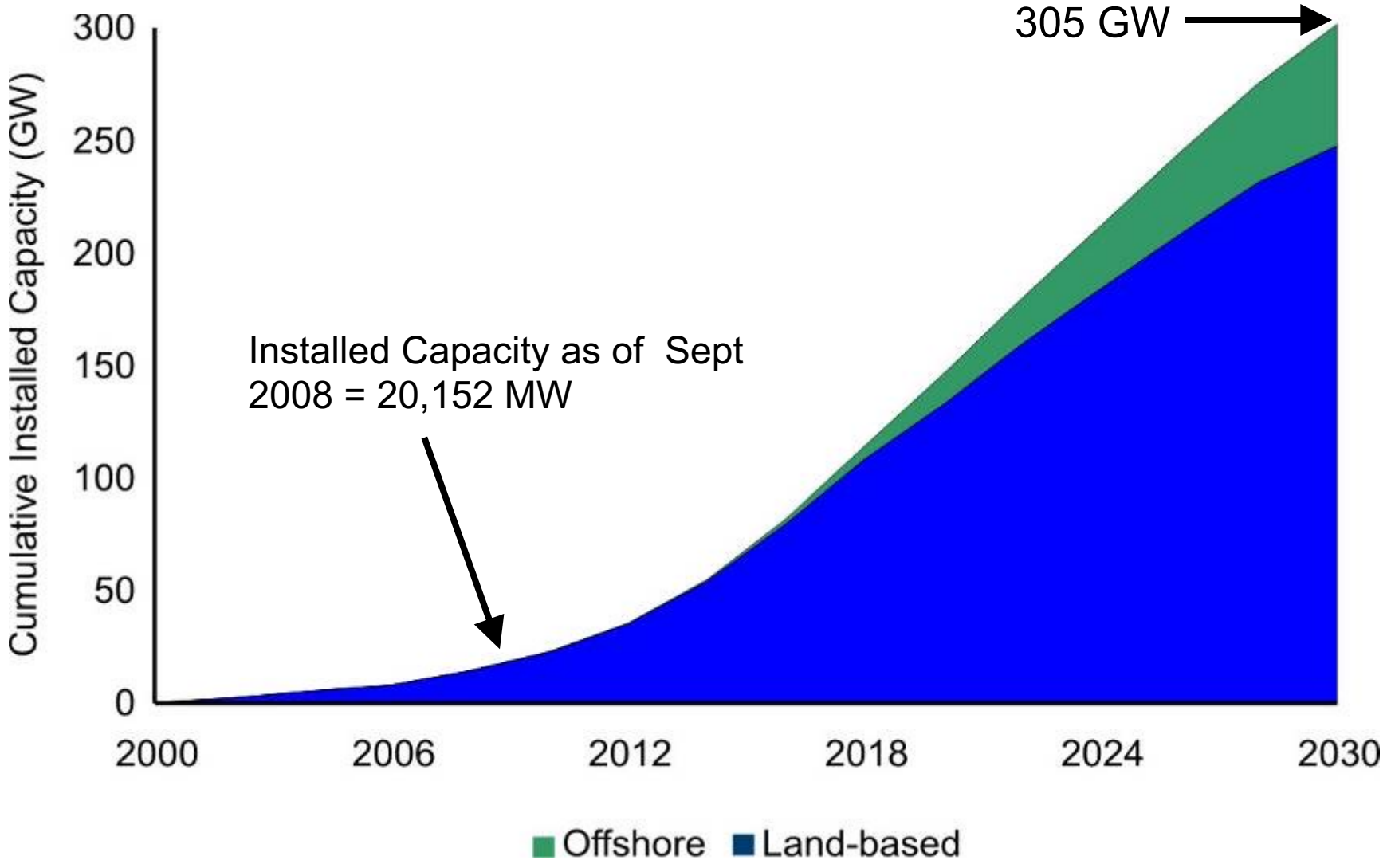
Average Wind Speed at 80 m



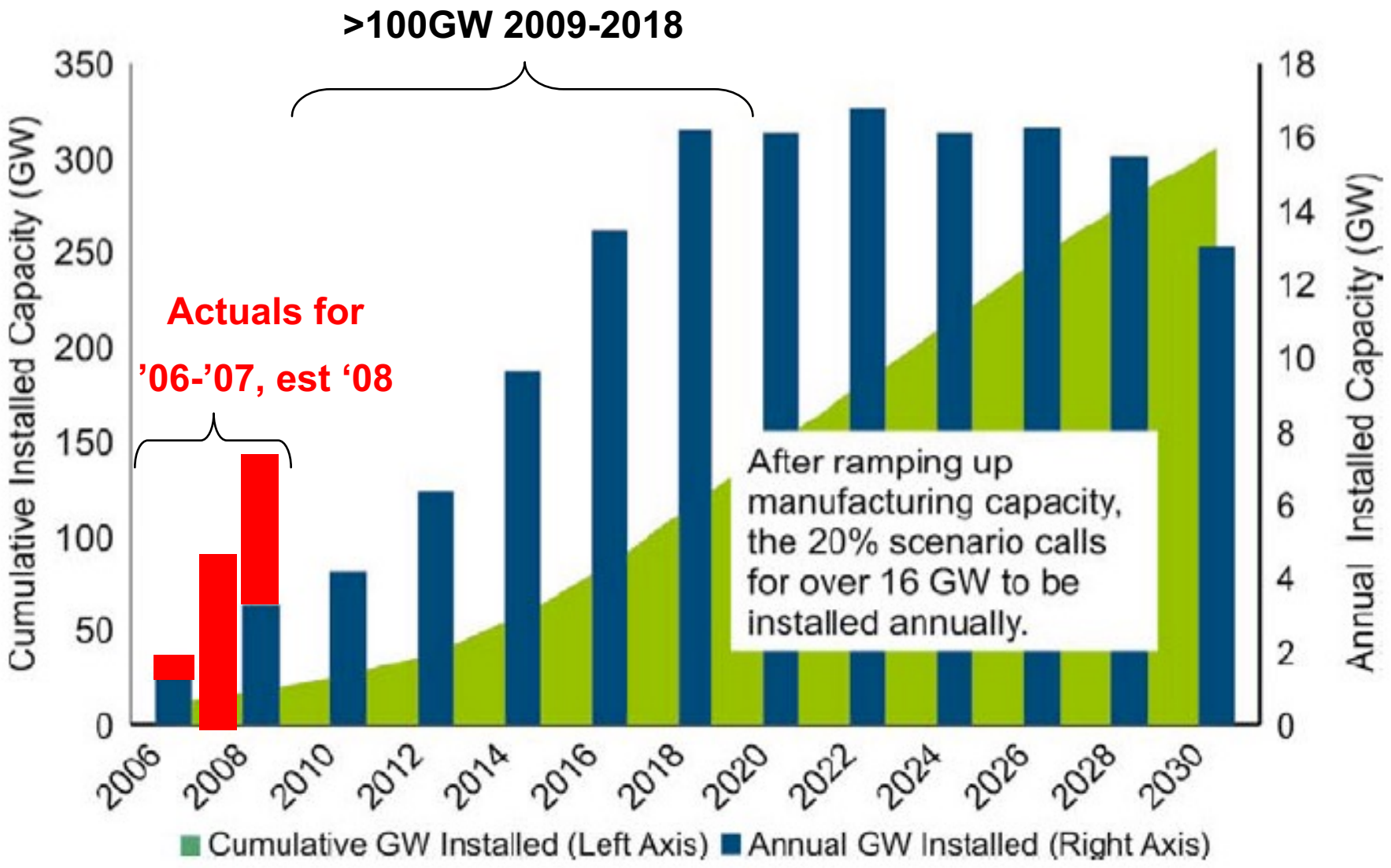
3TIER

U.S. National Wind Map

20% Wind Scenario

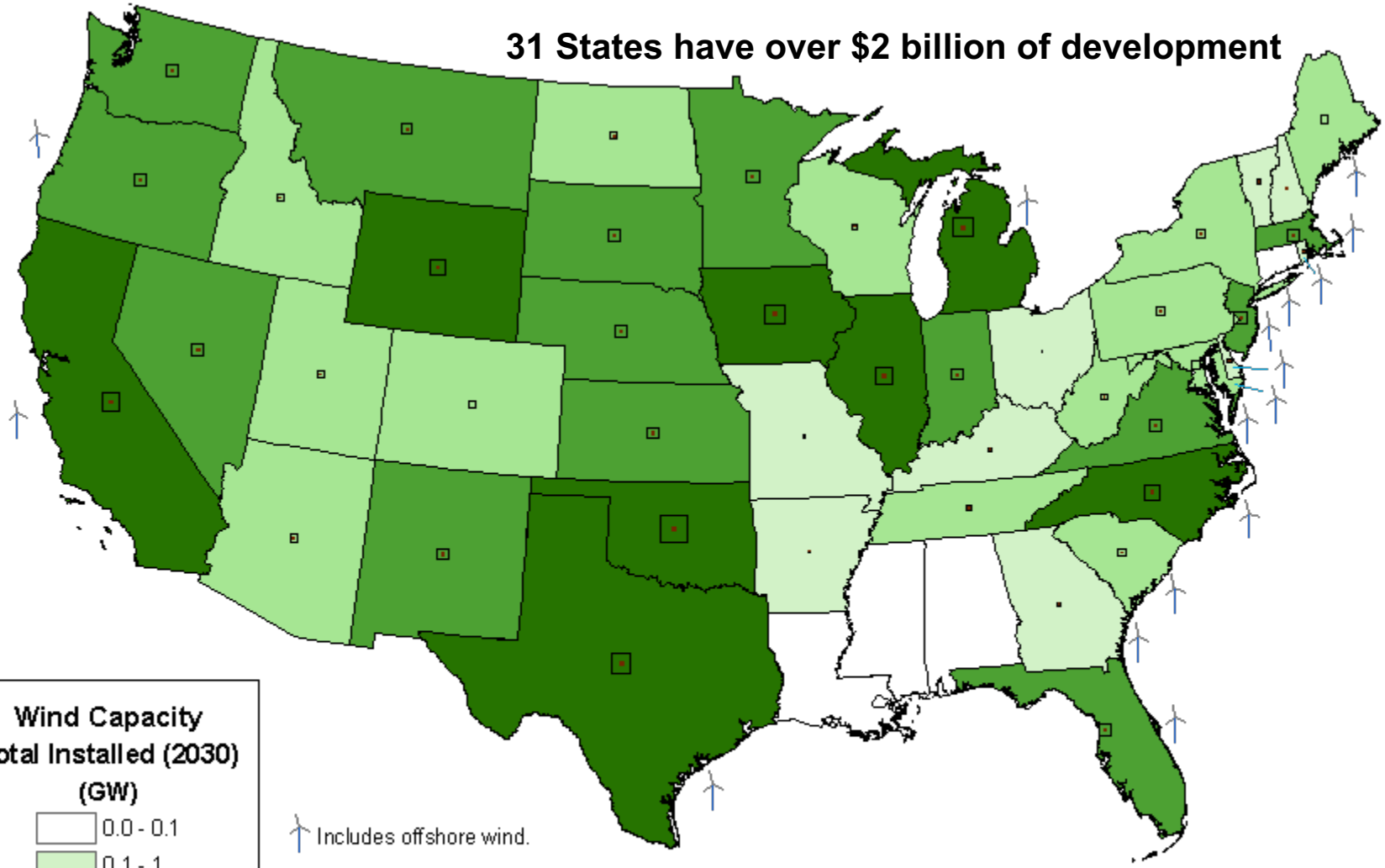


20% Wind Report: Growth Path For Wind



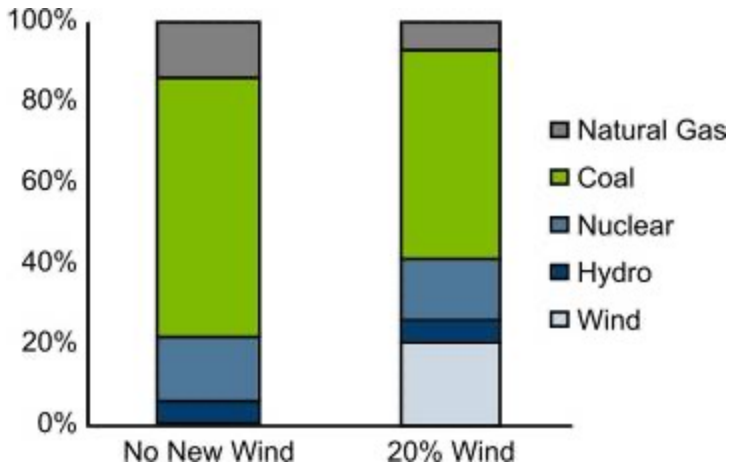
Preliminary: from forthcoming report

46 States Have Wind Development by 2030 Under the 20% Wind Scenario



The black open 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 brown square represents the actual land area that would be dedicated to the wind turbines (2% of the black open square).

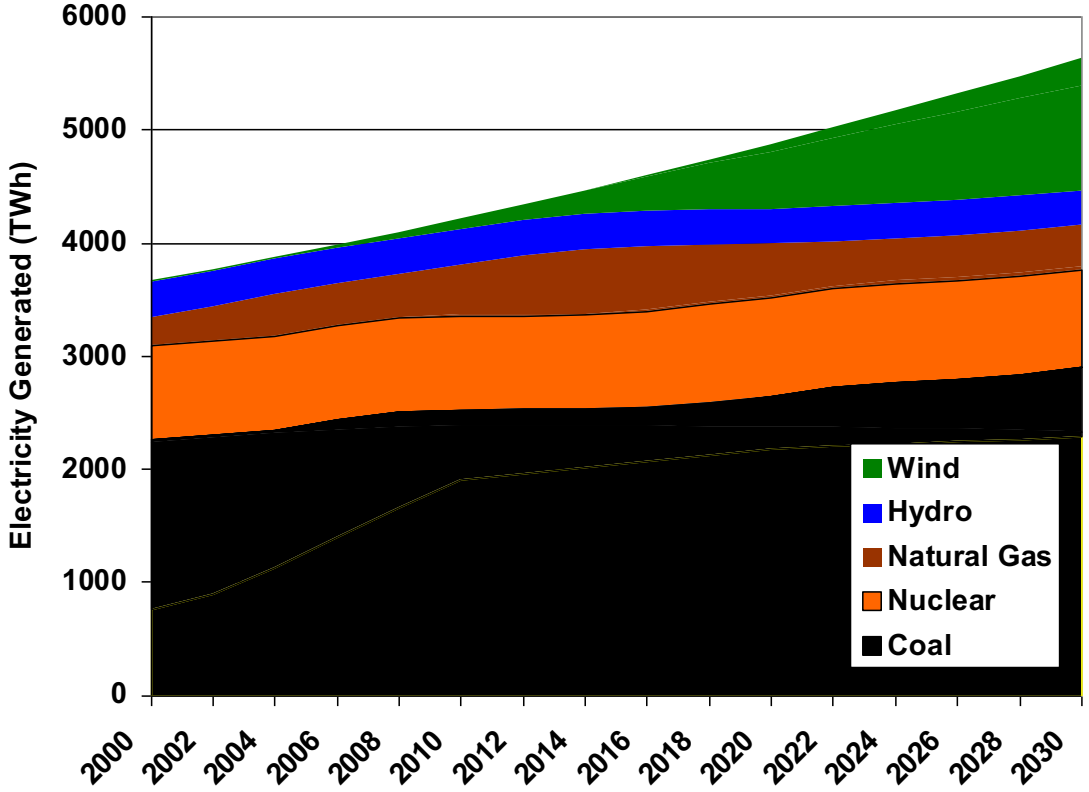
Wind Is Part of a Generation Portfolio



If Wind is 20% of 2030 generation, <u>80% is something else</u>

Other renewables assumed to stay at 2006 levels – clearly understated

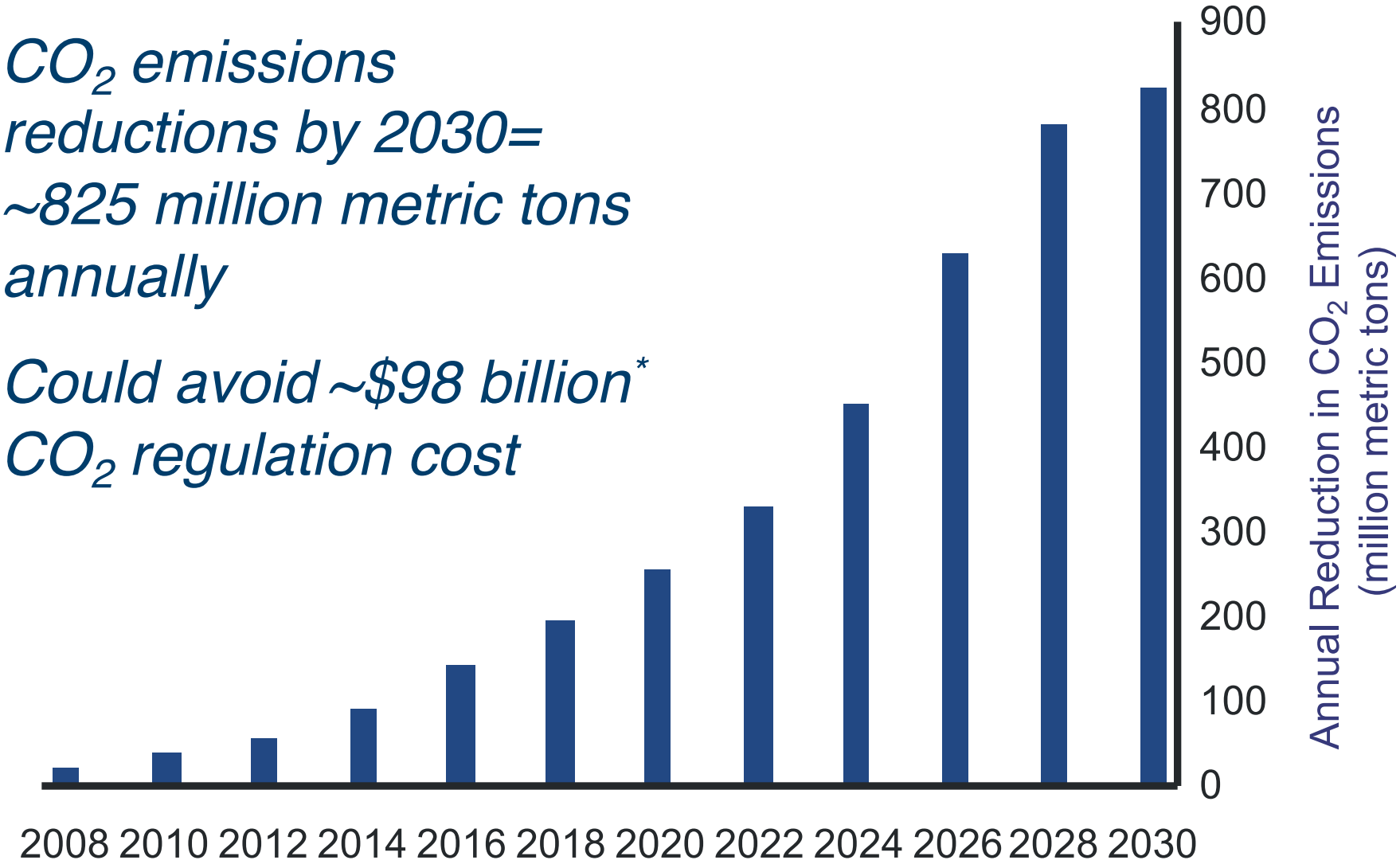
The 20% Wind Scenario would decrease generation from natural gas by 50% and generation from coal by 18%.



Annual CO_2 Emissions Reductions

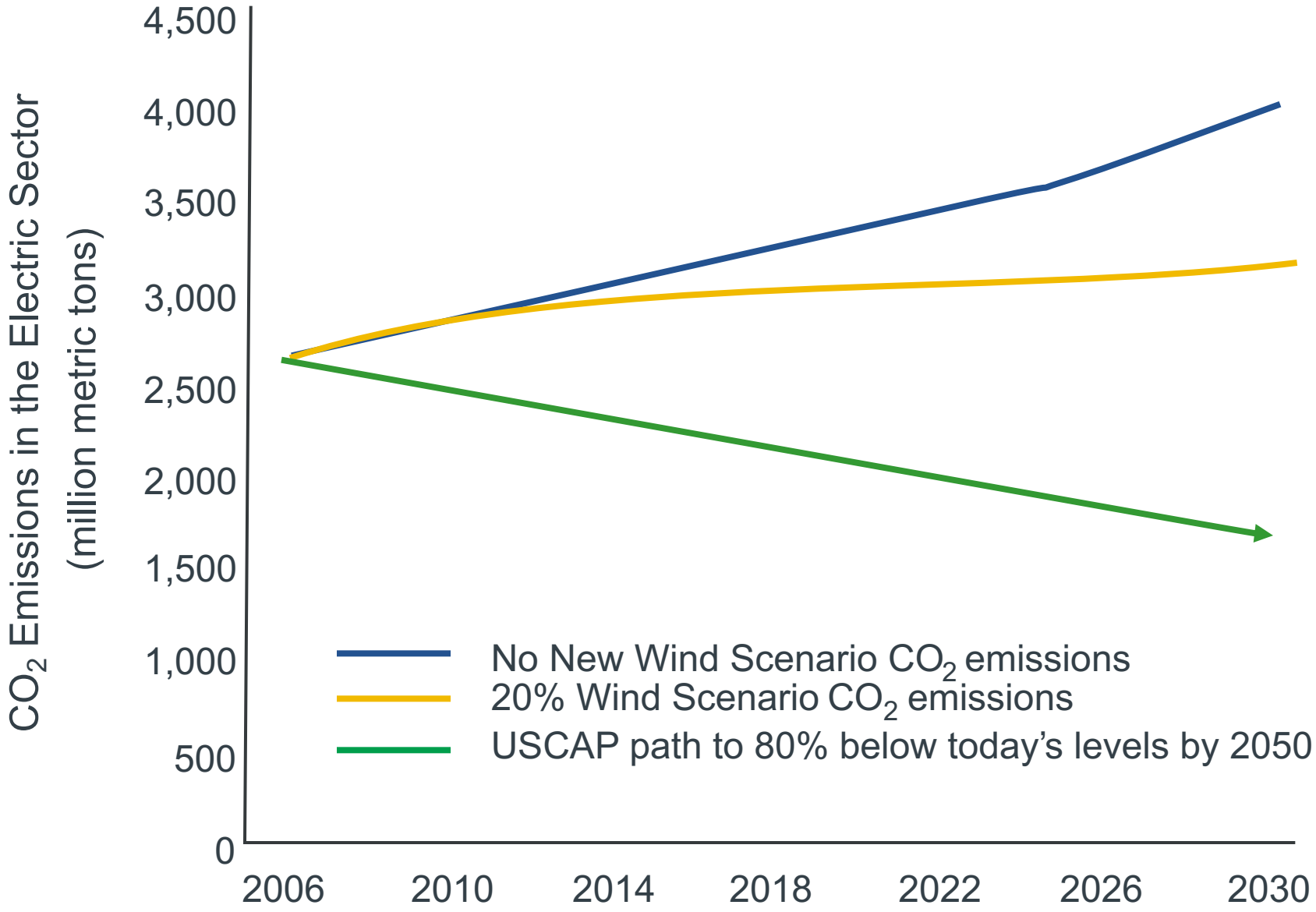
CO_2 emissions reductions by 2030= ~825 million metric tons annually

Could avoid ~$98 billion CO_2 regulation cost*



Source *: Hand et al., 2008

CO_2 Emissions from the Electricity Sector



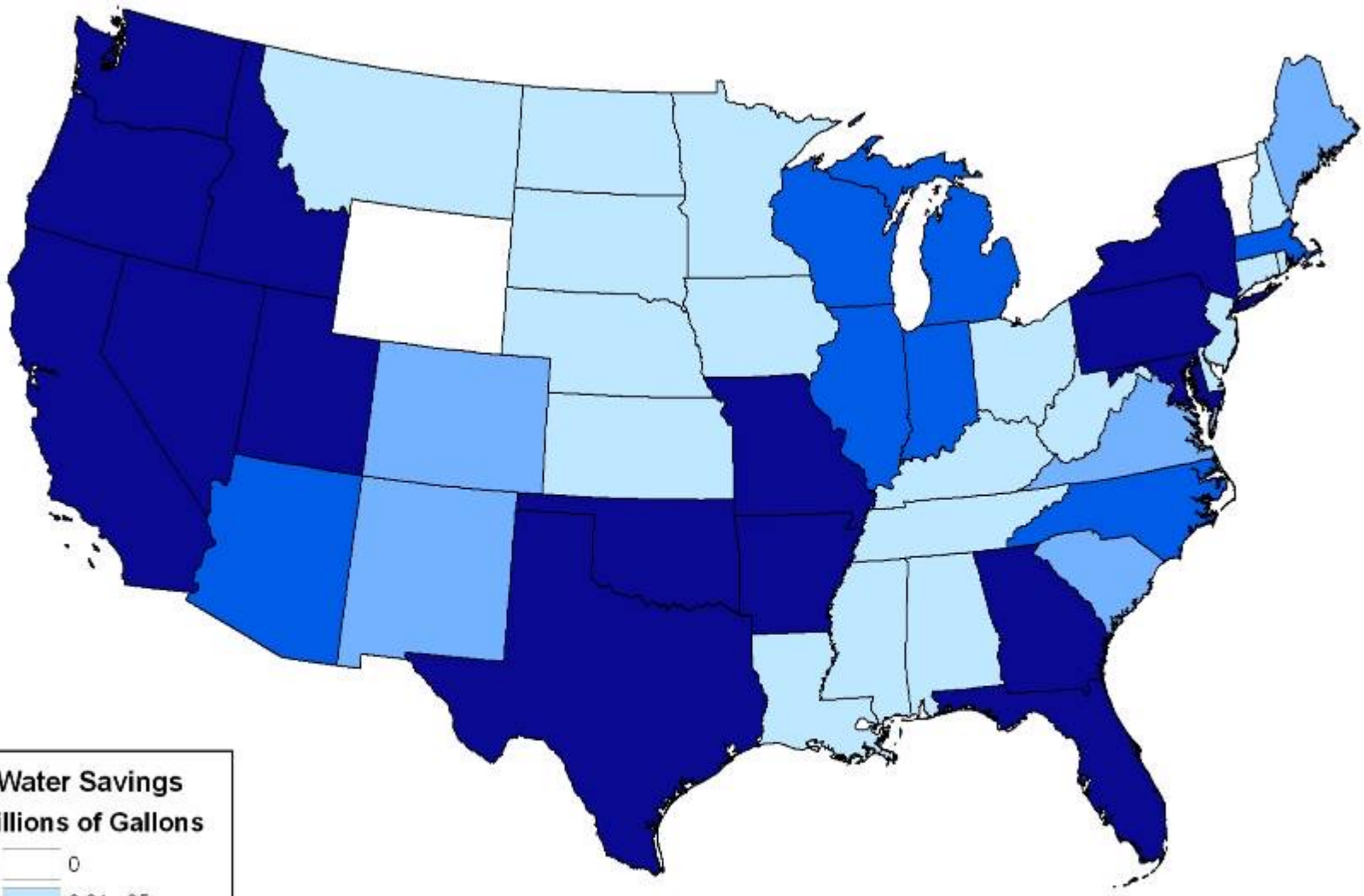
Wind is Ready to Lead the Fight Against Climate Change

2006 CO_2 Sources	Million Metric Tons/Year	Share of Total
Power Generation	2,328	41.3%
Transportation	1,856	32.9%
Industry	862	15.3%
Residential	327	5.8%
Commercial	210	3.7%
Other	55	1.0%
Total	5,638	100.0%

Source: US EPA Inventory of US GHG Emissions & Sinks 1990-2006

- 20% Wind in 2030 is equivalent to:
  - Taking 140 million of today's cars off the road, or
  - Increasing current vehicle fuel economy ~45% to 25 mpg, or
  - Offsetting 96% of the CO2 emissions of the entire 2007 US Industrial Sector
  - EPRI/NRDC estimates of GHG reductions from PHEVs in 2050

Cumulative Water Savings from 20% Scenario



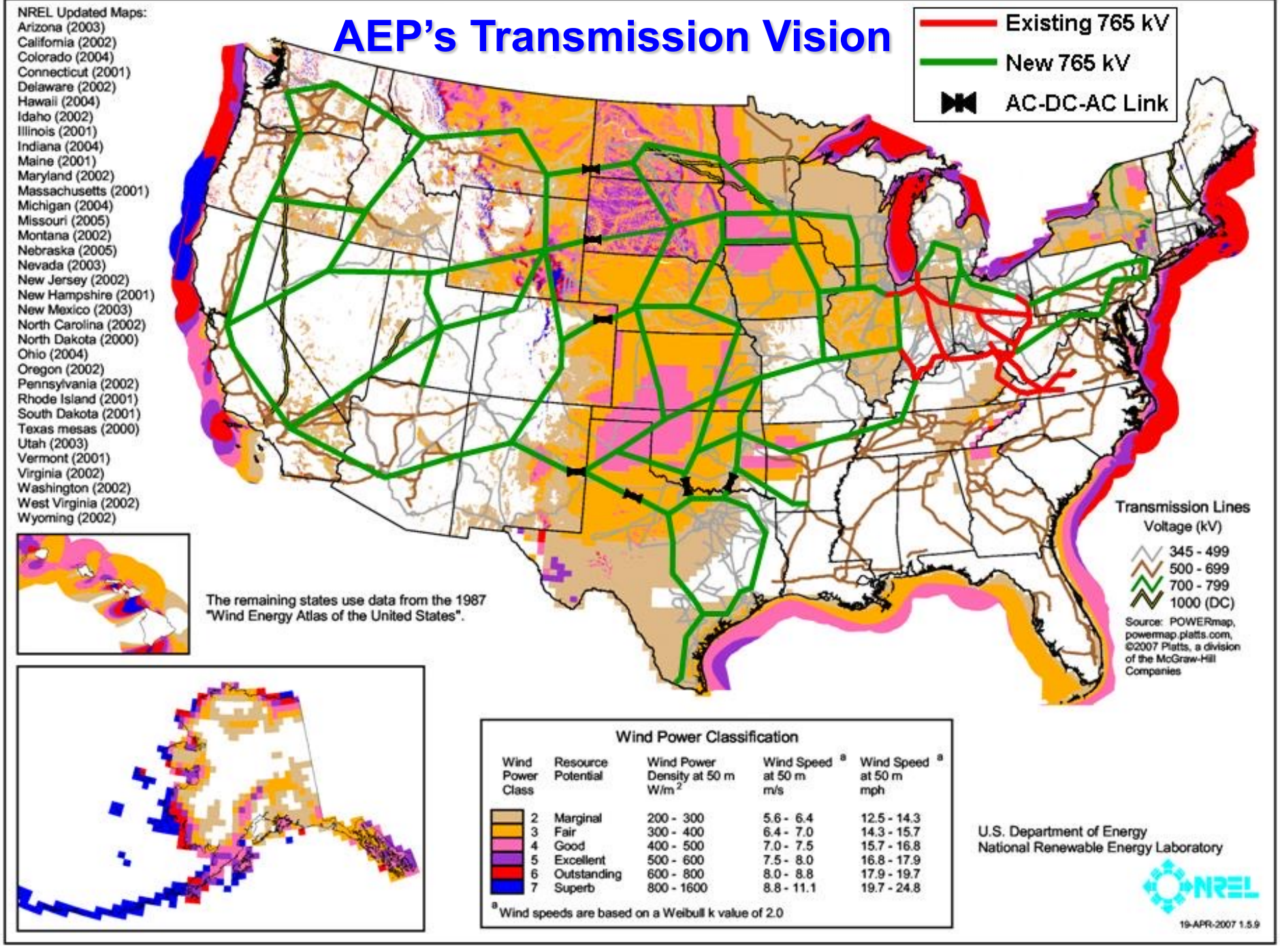
Reduces water consumption of 4 trillion gallons through 2030 (represents a reduction in electric sector water consumption by 17% in 2030)

Transmission

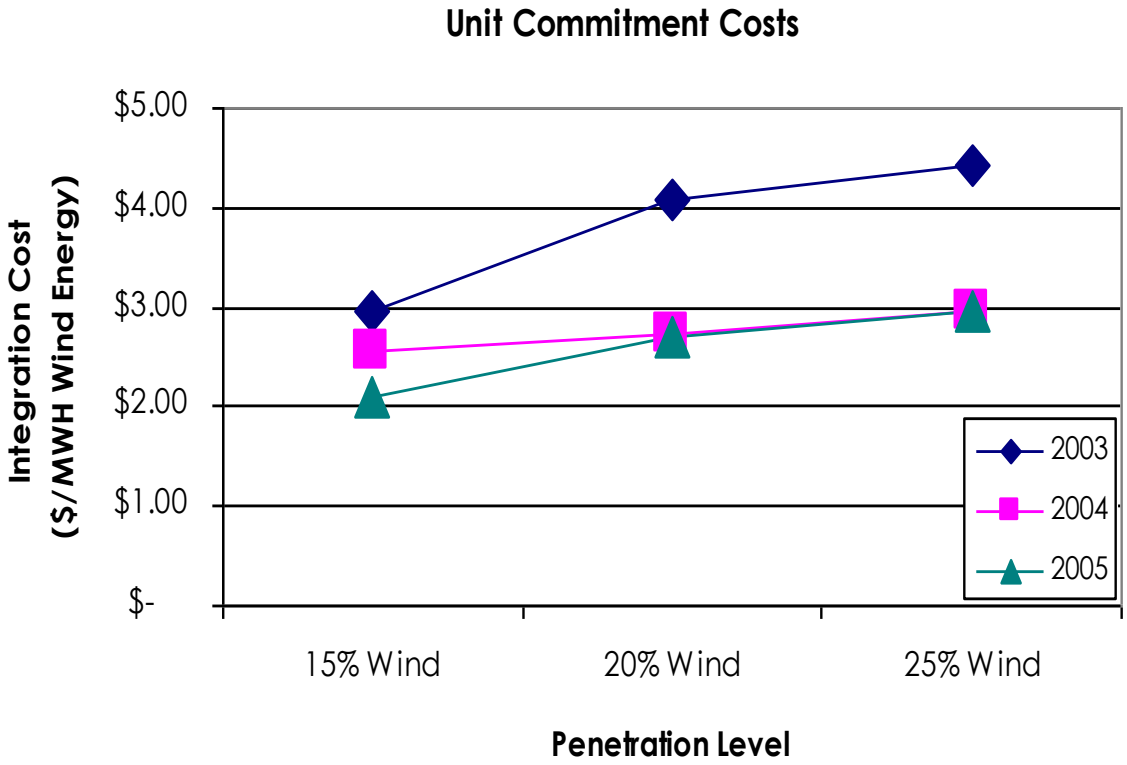
- Enhancement of electrical transmission system required in all electricity-growth scenarios
- Transmission is needed to:
  - Relieve congestion in existing system
  - Improve system reliability for all customers
  - Increase access to lower-cost energy
  - Access new and remote generation resources
- Wind requires more transmission than some other options as best winds are often in remote locations

Photo courtesy: NREL

AEP's Transmission Vision



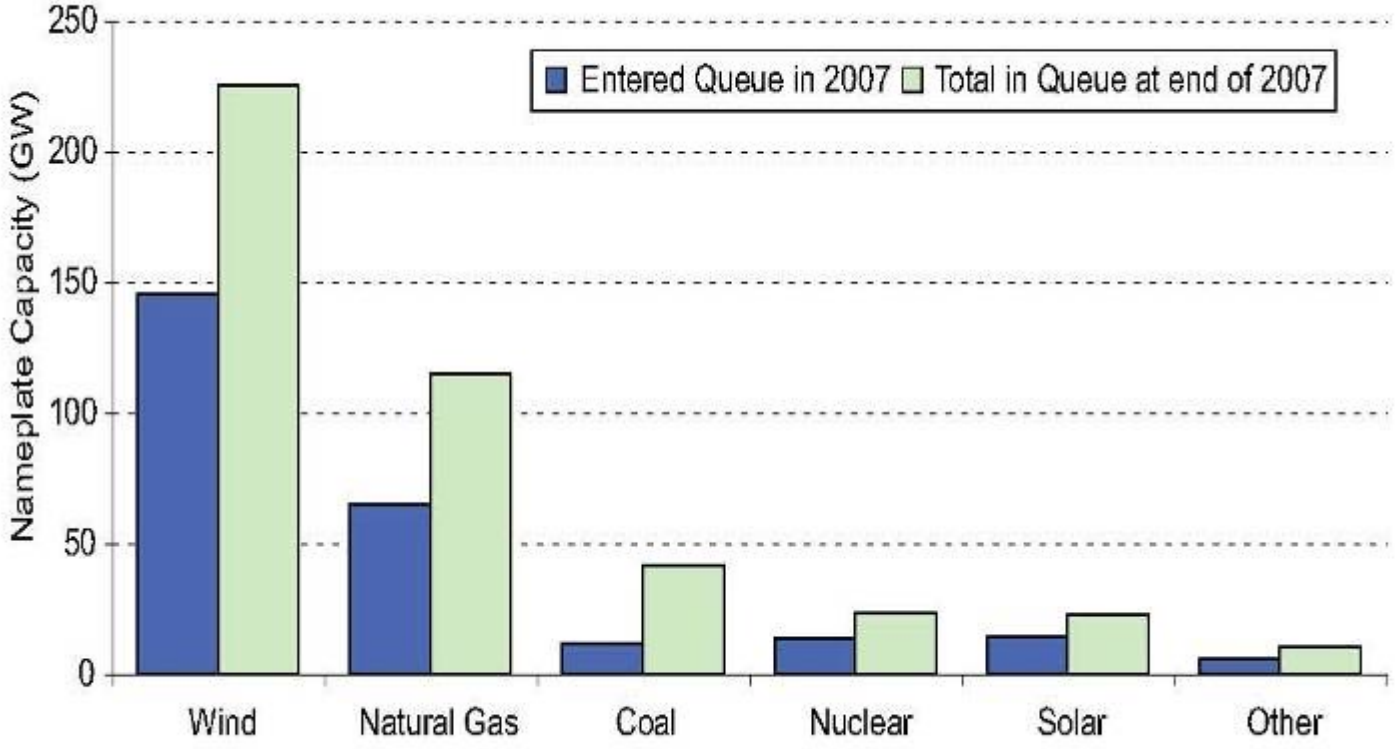
20% Wind Energy Can Be Managed



Wind integration costs for three penetration levels and pattern years. Cost of incremental operating reserves is embedded.

Source:
MN DOC

225,000 MW of wind now dominates 11 major interconnection queues



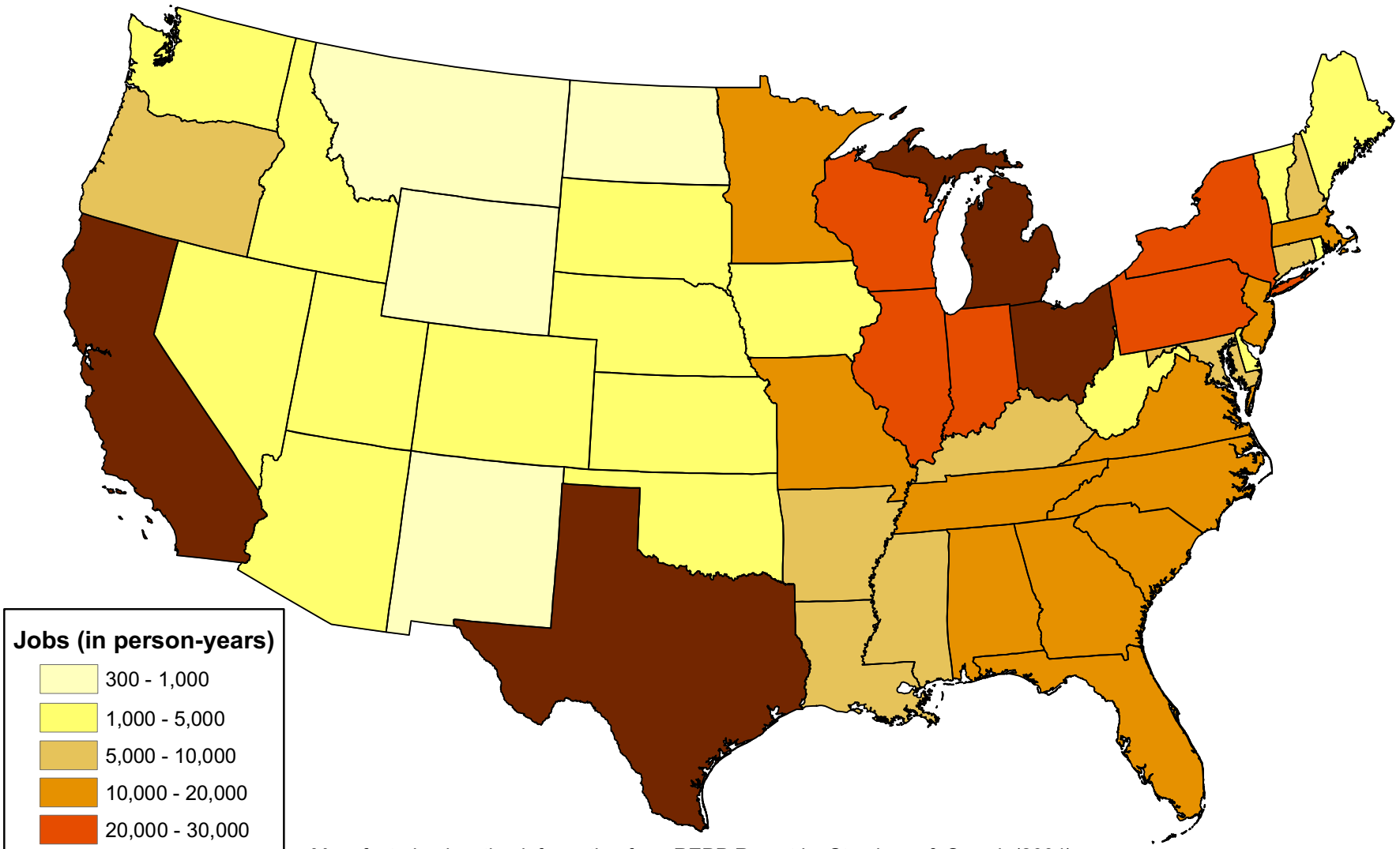
Source: Exeter Associates review of interconnection queues.

Jobs Supported by 20% Wind Scenario

Over 500,000 total jobs would be supported by the wind industry

Approx. 180,000 jobs supported directly by the wind industry in operations, construction, and manufacturing

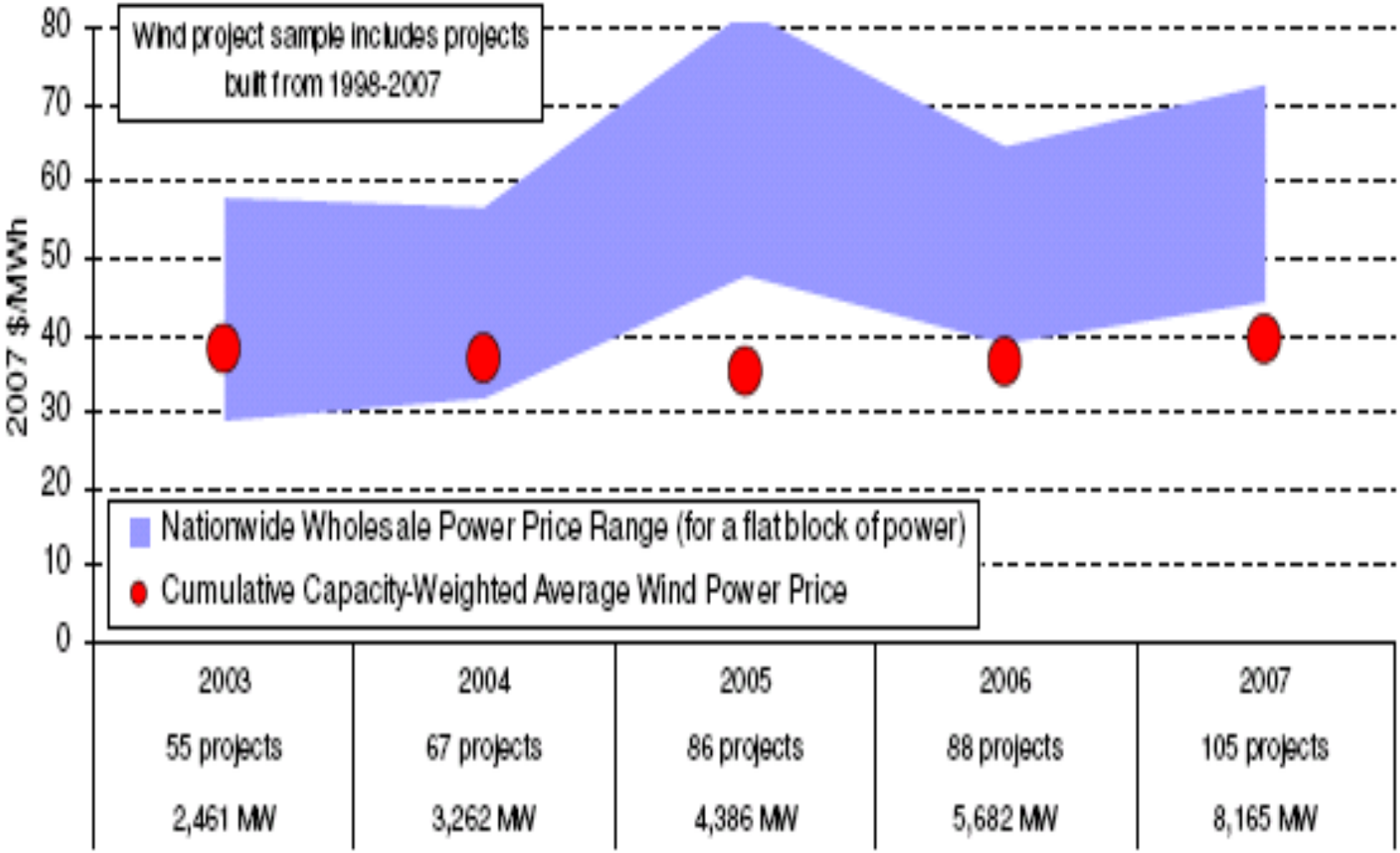
Manufacturing Jobs Supported by State



Manufacturing location information from REPP Report by Sterzinger & Svrcek (2004)

Major component assumptions: 50% of blades are manufactured in U.S. in 2007 increasing to 80% by 2030, 26% of towers are from the U.S. in 2007 increasing to 50% by 2030 and 20% of turbines are made in the U.S. increasing to 42% by 2030.

Wind is Competitively Priced



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

AVERAGE WIND AND WHOLESALE ELECTRIC PRICES

Summary: Costs & Benefits

Incremental direct cost to society	$43 billion 50 cents/month/ household
Reduction in emissions of greenhouse gasses and avoided carbon regulation costs	825 million tons of CO_2 $50 to $145 billion
Reduction in water consumption	8% through 2030 17% in 2030
Jobs supported and other economic benefits	500,000 total with 150,000 direct jobs $2 billion in local annual revenues
Reduction in nationwide natural gas use and likely savings for all gas consumers	11% $86-214 billion

Sources: DOE, 2008 and Hand et al., 2008

Note: All dollar values are in NPV

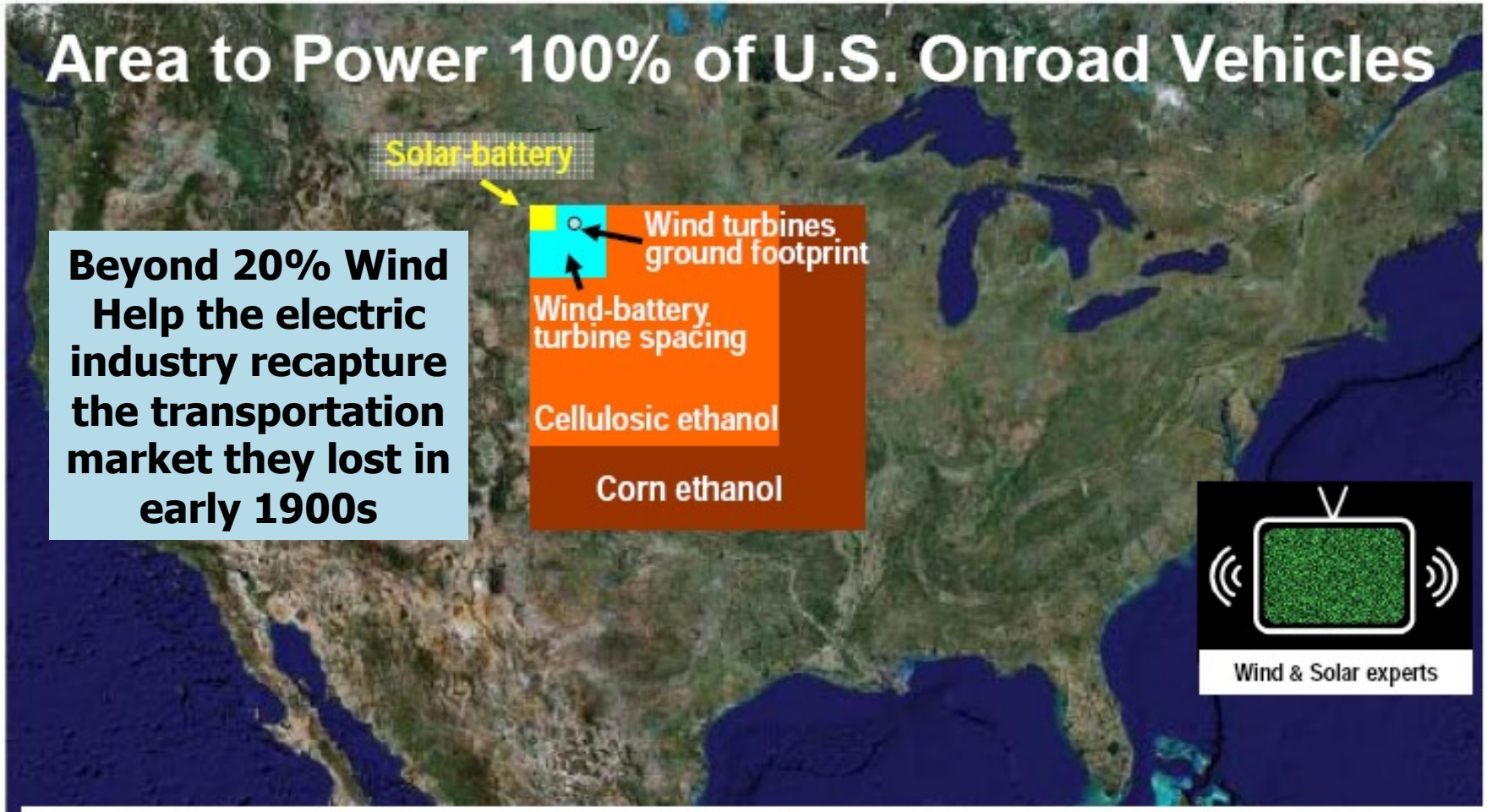
Beyond The 20% Wind Scenario

- The 20% Scenario in no way represents a "cap" – other scenarios could exceed 20%
- Plug-in Hybrid Electric Vehicles (PHEVs) present one scenario "beyond 20%"
  - US DOT reports that 78% of cars are driven < 40 miles per day on average; corresponds to expected battery range for PHEVs
  - Wind Power could charge PHEVs at night, off-peak, making better use of existing electric utility infrastructure
  - Smart Grid / advanced metering paves the way for PHEVs to truly be "wind powered cars"

Beyond The 20% Wind Scenario

- EPRI / NRDC Study:
  - If 60% of light vehicles replaced by PHEVs by 2050, electricity consumption would rise only about 8%.
  - Net carbon dioxide reductions of 450 million metric tons annually—equivalent to taking 82 million cars off the road.
- PNWNL Study:
  - Found the existing US electric system has the "technical potential" to support 73% penetration of LDV fleet by PHEVs
  - Would reduce US GHG emissions 27%, oil imports 52%
- Expanding wind power will help ensure that PHEV growth results in emissions and electricity price reductions

Area to Power 100% of U.S. Onroad Vehicles



Beyond 20% Wind
Help the electric industry recapture the transportation market they lost in early 1900s

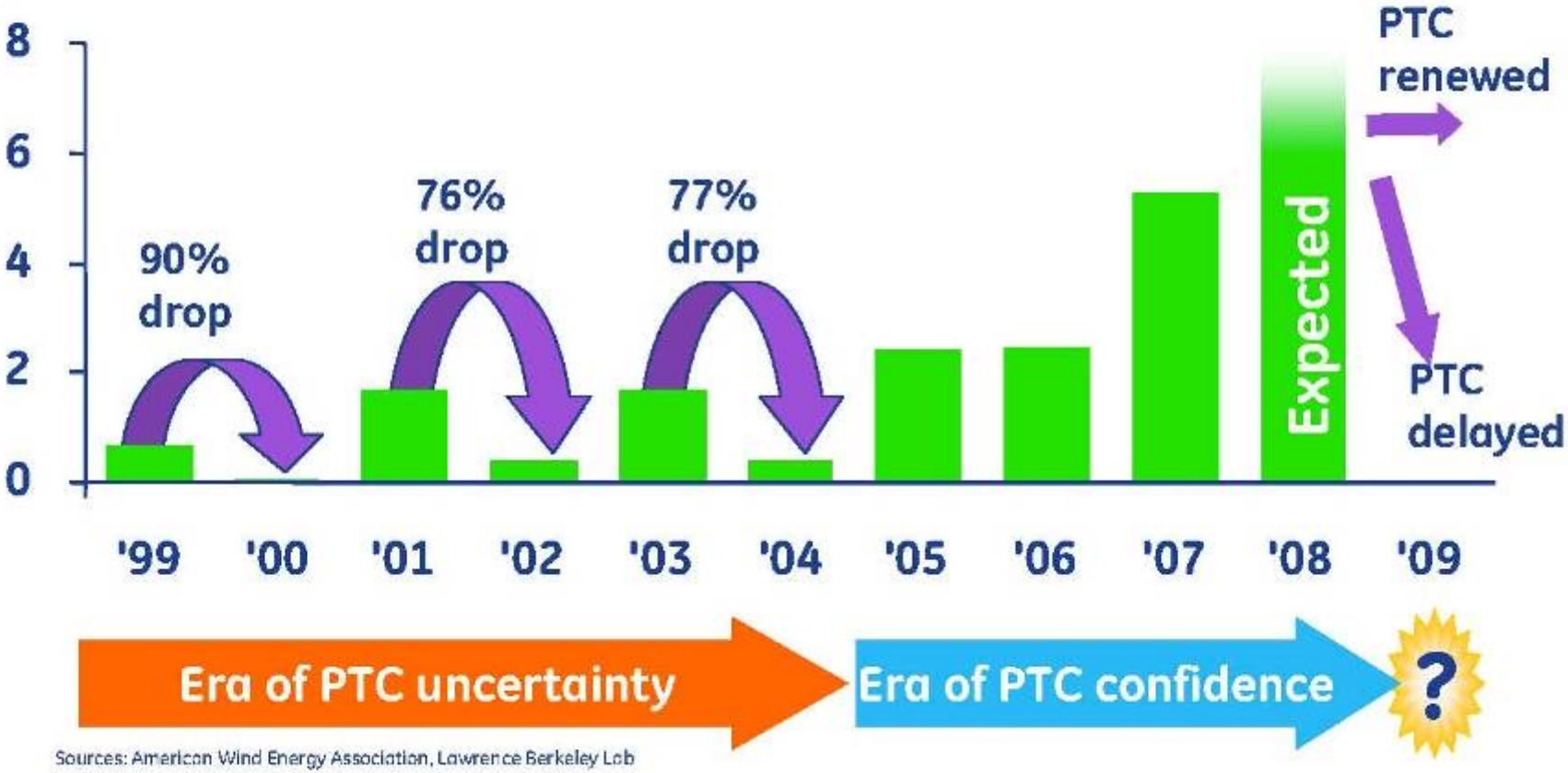
Solar-battery and Wind-battery refer to battery storage of these intermittent renewable resources in plug-in electric driven vehicles

WEB CALCULATOR- VISUALIZER – COMPARISON OF LAND NEEDED TO POWER VEHICLES

Mark Z. Jacobson, Wind Versus Biofuels for Addressing Climate, Health, and Energy, Atmosphere/Energy Program, Dept. of Civil & Environmental Engineering, Stanford University, March 5, 2007, http://www.stanford.edu/group/efmh/jacobson/E85vWindSol

Stable Policy Critical for Sustained Growth

US wind annual capacity additions
(Gigawatts)



Sources: American Wind Energy Association, Lawrence Berkeley Lab

Can We Do It?

- During WWII, US was arsenal to the world
  - FDR promised 60,000 airplanes, delivered 229,600
  - EVERYBODY pitched in.
- Then it took 37% of GDP, 87% of Federal budget
- Today we have the resources to do 300 GW using only 2.5% of US steel production (Black & Veatch)
- US Auto Industry in 2007 produced the horsepower equivalent of 1,700 GW – 100 times the annual rate of prime mover production needed for 20% wind

Conclusions

- 20% Wind Report provides authoritative confirmation that wind has great growth potential
- There are no fundamental technical barriers to the integration of 20% wind energy into the nation's electrical system, but…
- Requires a continuing evolution of transmission planning, system operations and market development for this to be achieved
- Scenario is feasible and brings significant net benefits
- Scenario is not a cap – potential exists for accelerating schedule (e.g. Pickens Plan) going beyond 305GW to help transform transportation
- Climate change and import dependence add great urgency – Nobelist Pachauri, IPCC Head, says we have only 7 years (to 2015) to have world GHG emissions start to decline to avoid temperature rises > 2C
- Wind can provide a bridge to other clean generation technologies
- **Wind is one of a very few zero carbon, zero water use, affordably priced generation sources that can and is being deployed at scale using current technology**