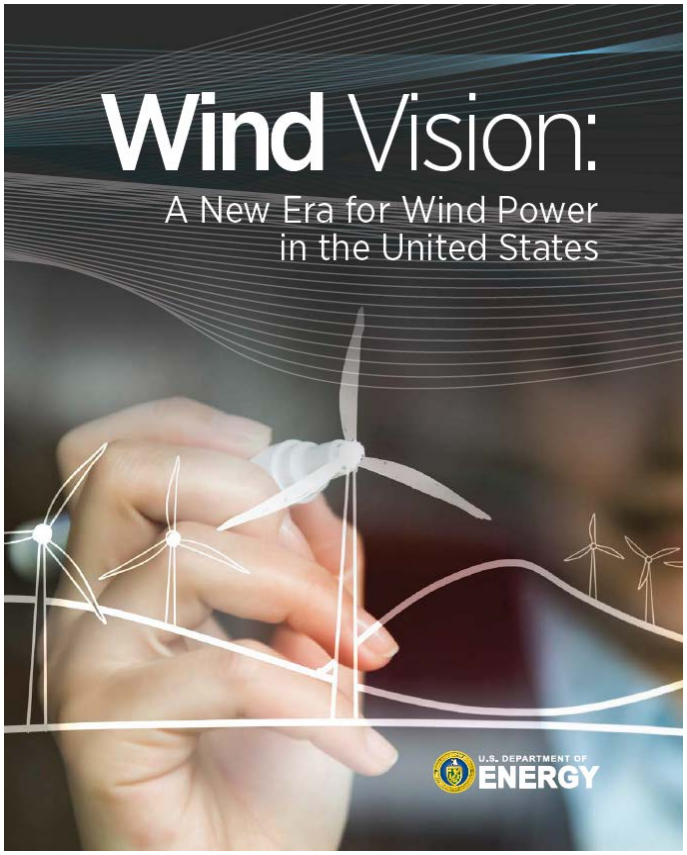


The DOE Wind Vision: Costs, Benefits and Other Impacts

Ed DeMeo

Renewable Energy Consulting Services, Inc.

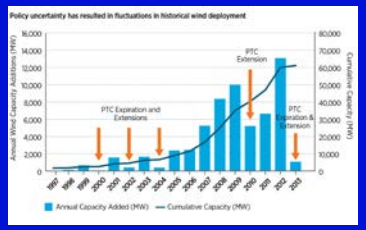
(DOE Wind Vision Core Management Team)

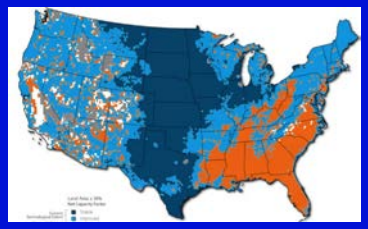
NAWEA 2015 Symposium

June 9, 2015 Blacksburg, Virginia

Renewable Energy
Consulting Services, Inc.

Discussion Topics





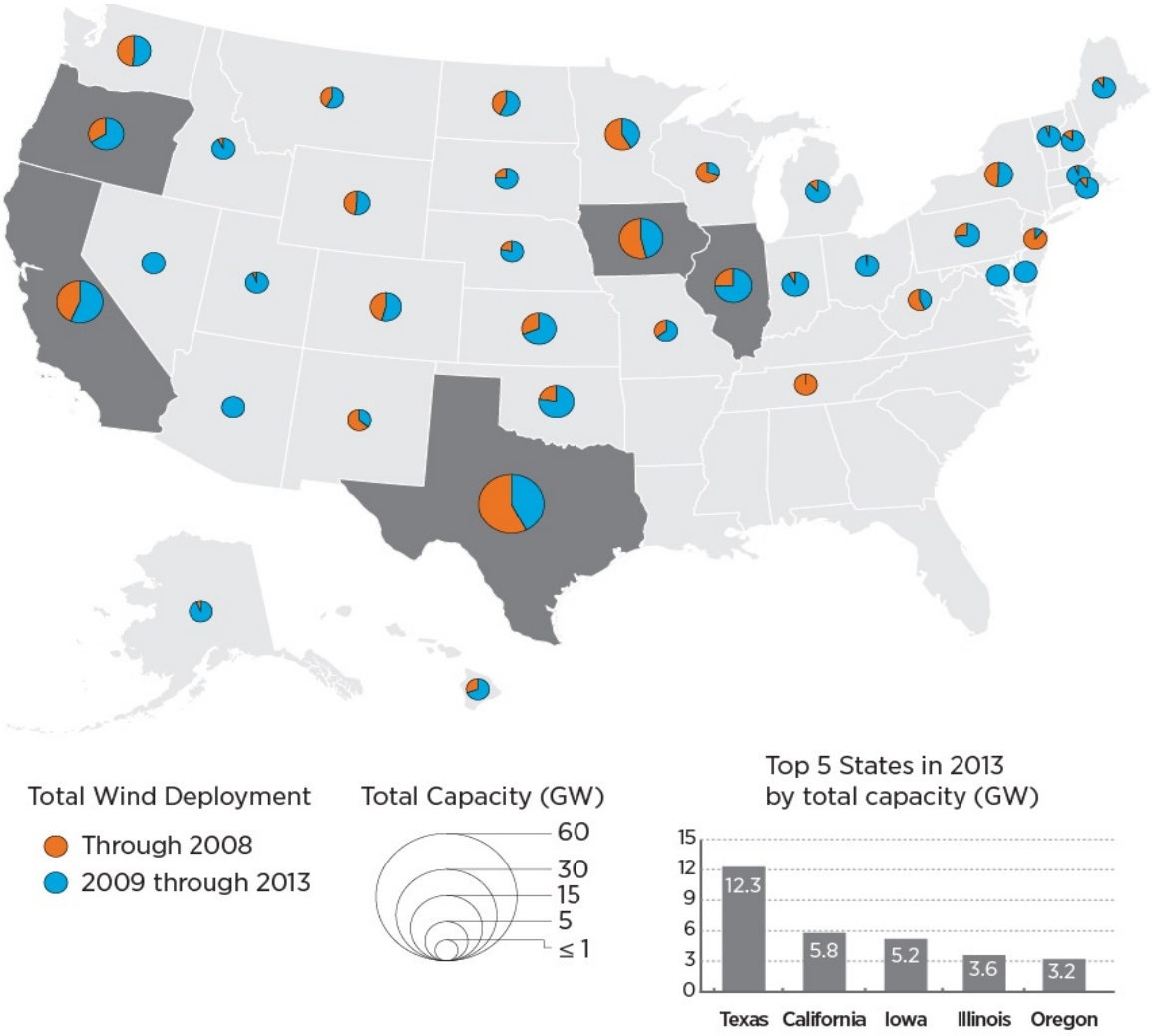
- Highlights of New DOE Wind Vision findings
- Focus on costs, benefits, and other impacts
- Implications for wind deployment going forward
- Prospects for regional expansion

- An assessment of wind power's status, prospects and contributions over the next three decades: costs, benefits, other impacts
- Conducted by over 250 experts in wind, electric power, and the environment
- Released March 2015 by the U.S. Department of Energy

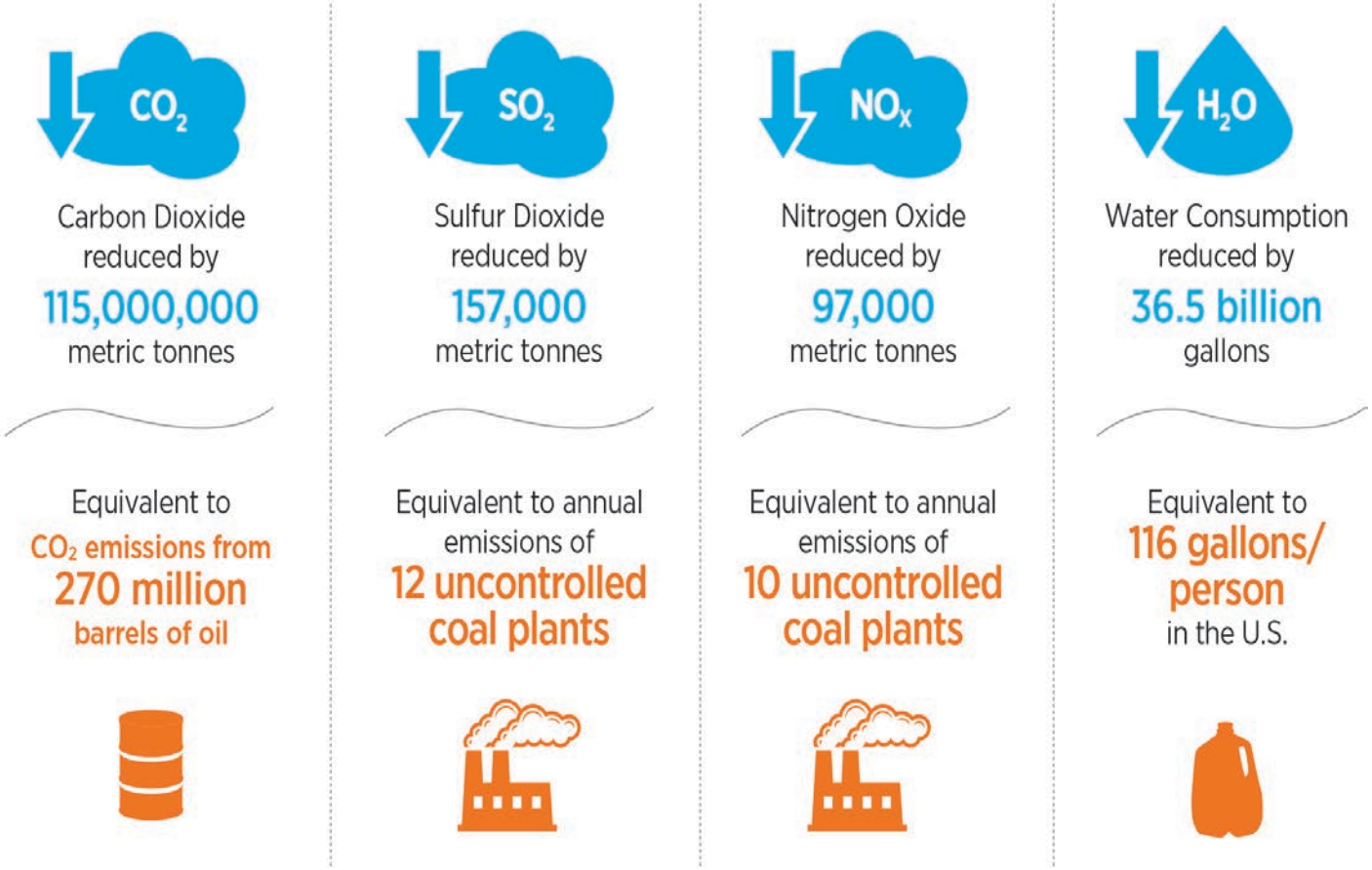
Key Wind Facts

- **4.6% of U.S. 2014** power generation
- **42%** of all 2012 U.S. power capacity additions, the highest of any resource (investment of **$25 billion**)
- **59 GW wind capacity added from 2005 to 2014**
- **11 states with > 10% wind** generation in 2014: *Colorado, Idaho, Iowa, Kansas, Maine, Minnesota, North Dakota, Oklahoma, Oregon, South Dakota, and Texas*
- **Two states with >25%** wind generation in 2014: *Iowa (30%) and South Dakota (25%)*
- **Average of 73,000 U.S. jobs** in installation, manufacturing and operations over 2010-2014

Cumulative utility-scale wind deployment reached 61 GW across 39 states in 2013



Wind Energy Is Delivering a Variety of Environmental Benefits Now



Note: Emissions and water savings calculated using the EPA's Avoided Emissions and Generation Tool (AVERT). 'Uncontrolled coal plants' are those with no emissions control technology.

Key Fact

The avoided CO_2 emissions from wind energy today help offset the equivalent of more than 24 million passenger vehicles

Wind Is A Reliable Source of Electricity

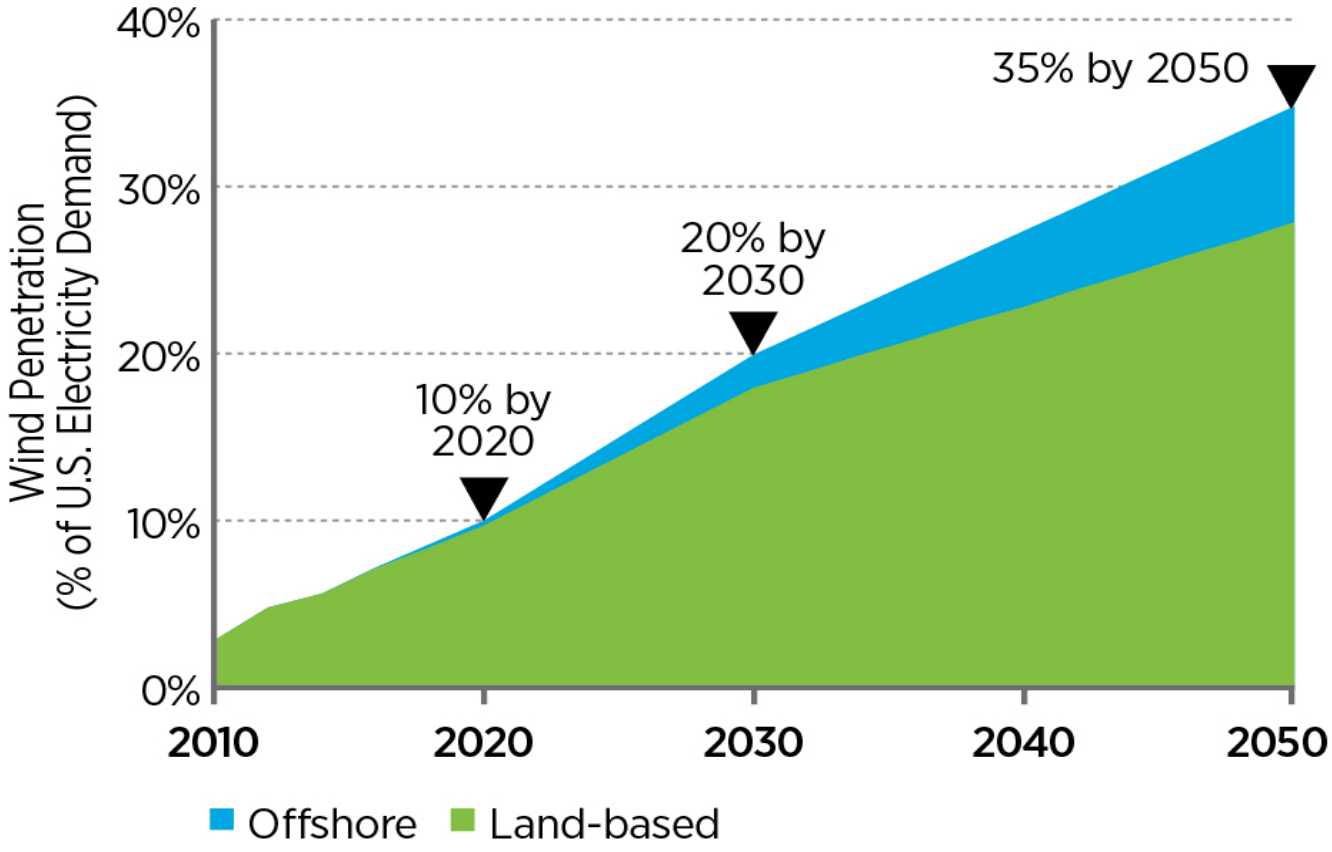
Yes, the lights will stay on!

- Very high shares of wind -- 30% to 60% instantaneously -- have not brought the power system down
- Several major electric utility operators now get over 10% of their annual generation from wind power
- Wind has helped the Texas power grid operator avoid blackouts when extreme drought forced curtailment of fossil-fueled plants

Wind is variable and controlled largely by nature, but the myth that the power system can't accommodate it has been disproven by actual operating experience

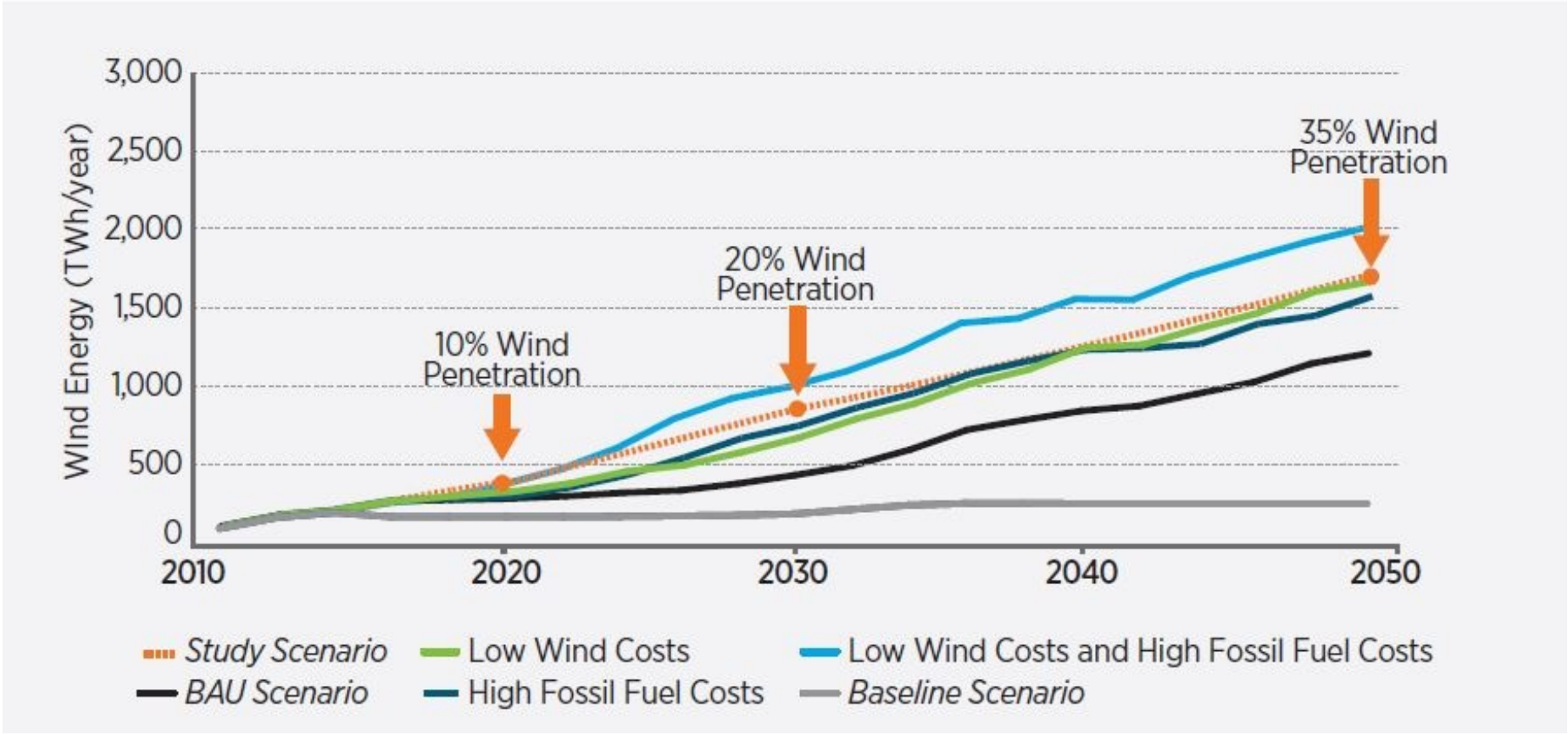
Wind Growth Scenario

Aggressive but Reasonable



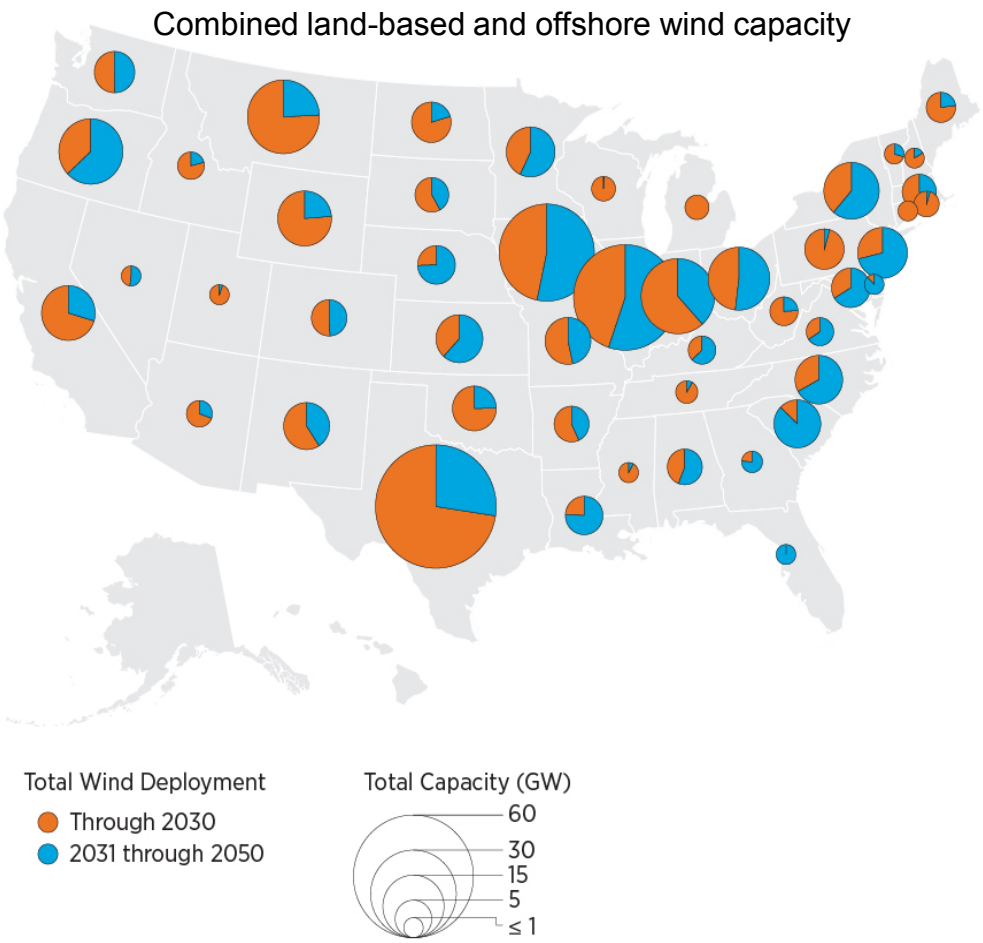
- Compare this to a baseline scenario with no new wind after 2013
- Requires 8 to 10 GW/year of new wind

Wind Vision Sensitivity Scenarios



With Business as Usual (BAU – no incentives), wind deployment is minimal for the next 10 to 15 years.

Wind Vision Scenario Yields Broad Geographic Distribution of Wind Capacity



Note: Results presented are for the *Central Study Scenario*. Across *Study Scenario* sensitivites, deployment by state may vary depending on changes in wind technology, regional fossil fuel prices, and other factors. ReEDS model decision-making reflects a national optimization perspective. Actual distribution of wind capacity will be affected by local, regional, and other factors not fully represented here. Alaska and Hawaii already had wind deployment in 2013. However, future deployment estimates are limited to the 48 contiguous United States due to modeling limitations.

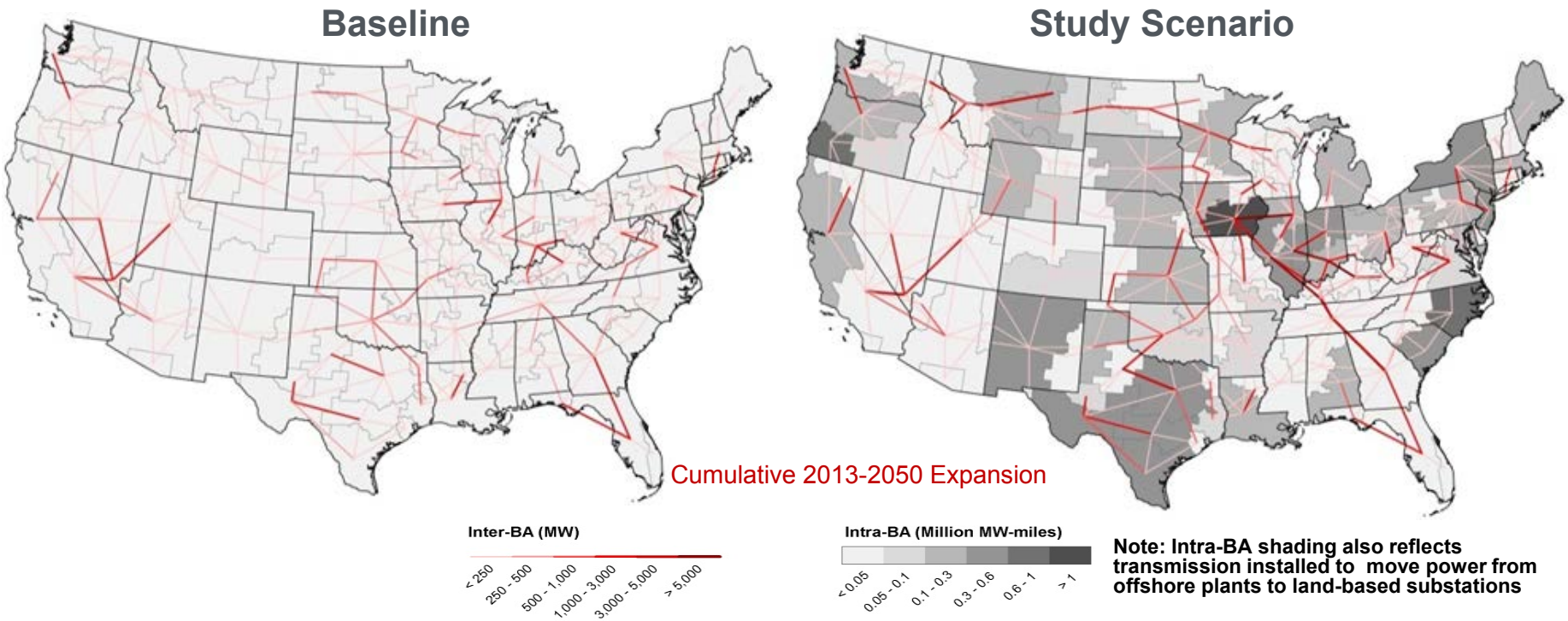
Wind deployment is found to be geographically widespread; in the Central Study Scenario:

- **all 48 (continental) states participate in the Vision by 2050** *[compared with 39 today]; and*
- **37 states have over 1,000 MW of wind by 2030**; **40 states by 2050** *[compared with 16 today]*

Range of deployment possibilities exist for any state due to possible future conditions (e.g. fuel prices, legislation, incentives, access to transmission, permitting)

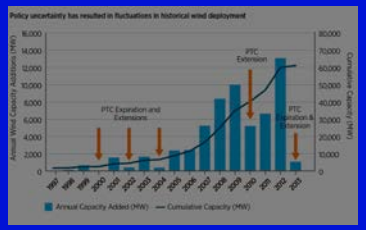
Example Results to Inform Priorities: Transmission Expansion

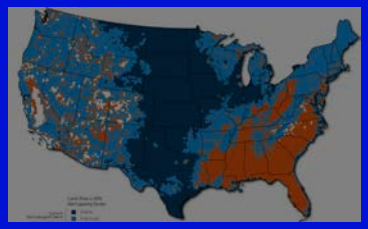
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



- Study Scenario **2030** transmission needs, less than **10% greater than the estimated 200 million MW-miles in place today** (approximately 11,000 miles of new transmission, assuming typical 345 kV carrying capacity)
- Study Scenario **2050** transmission needs, less than **20% greater than the estimated 200 million MW-miles in place today** (approximately 33,000 miles of new transmission, assuming typical 345 kV carrying capacity)
- Long-distance transmission **builds are spread across the U.S., but more concentrated in the Mid-West, Texas, and the West**
- Additional transmission investment is estimated at approximately **$70 billion or 0.5 cents/kWh-wind**

Discussion Topics





- Highlights of New DOE Wind Vision findings
- **Focus on costs, benefits, and other impacts**
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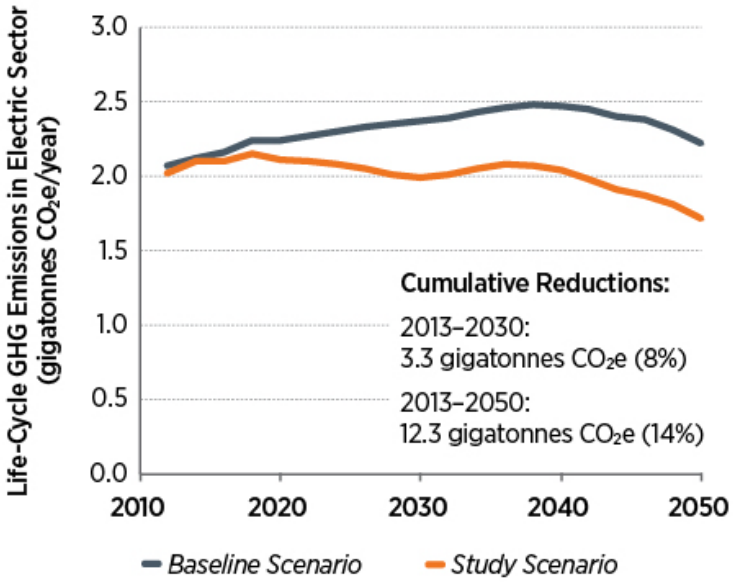
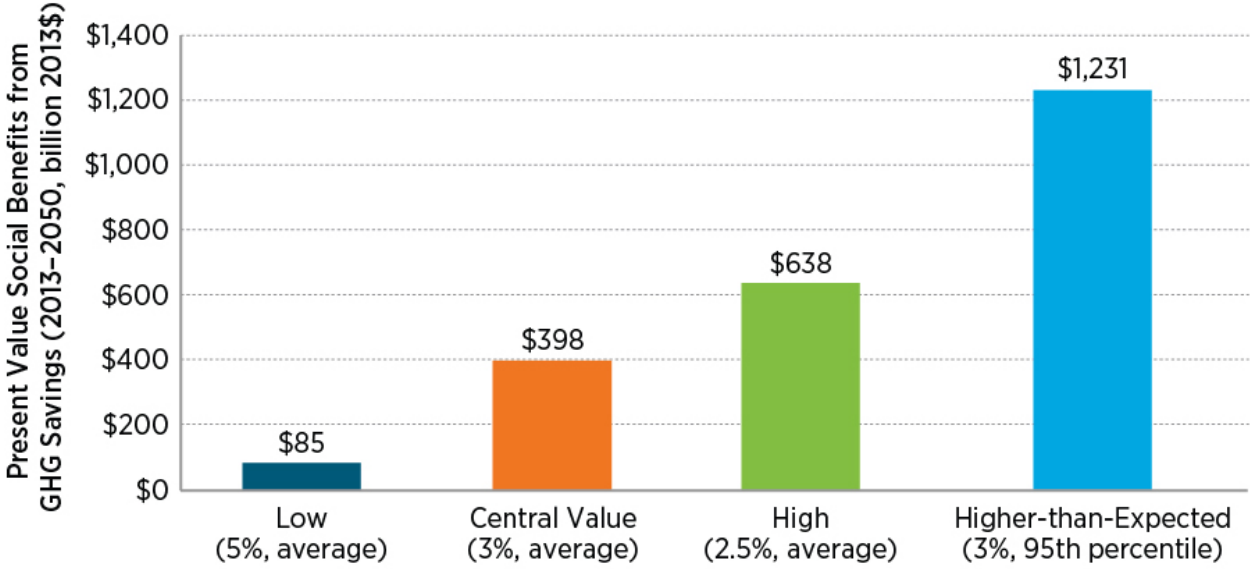
Wind Vision Scenario Reduces Damages from Global Climate Change

Wind Vision results in life-cycle GHG savings in U.S. power sector of **6% in 2020**, **16% in 2030** and **23% in 2050** relative to No New Wind; economic value of those reductions estimated with IWG Social Cost of Carbon





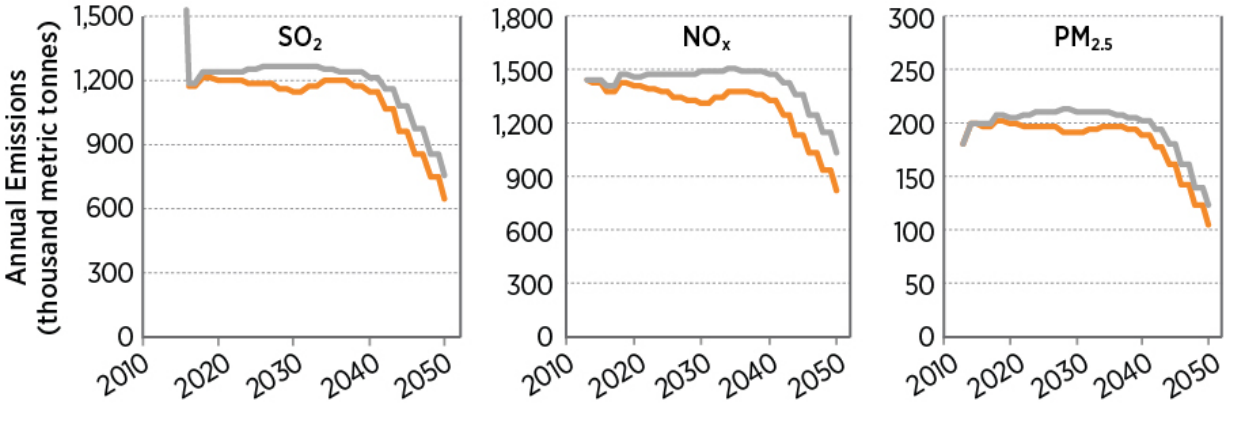
Social benefits are equivalent to:

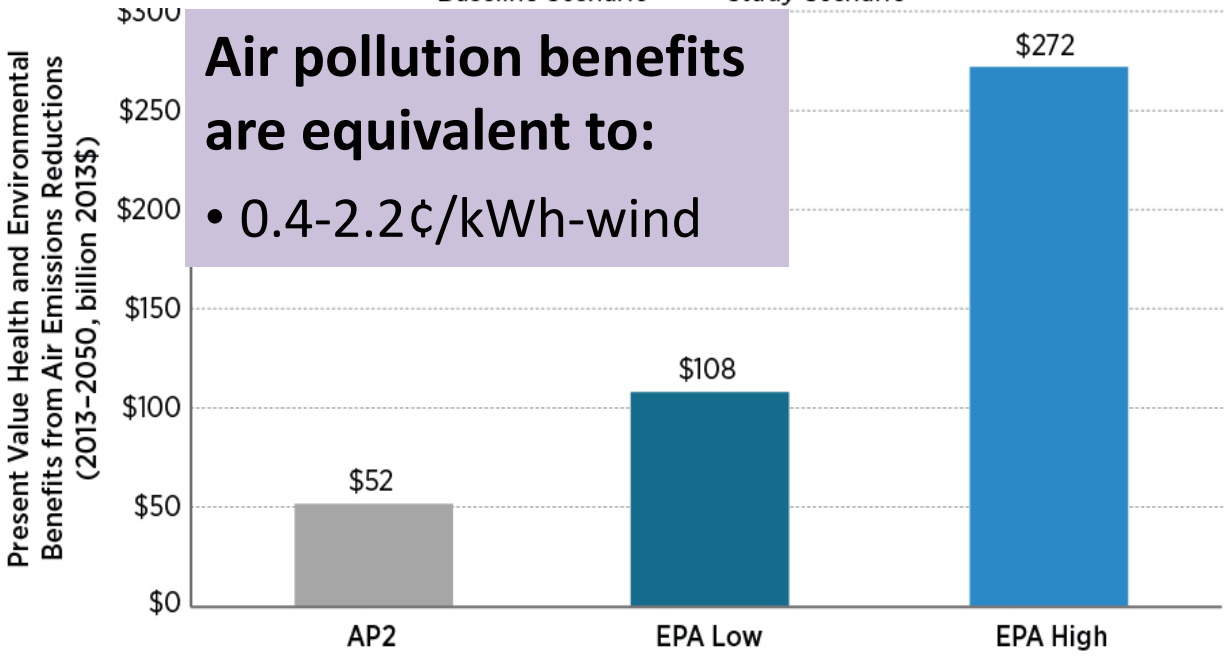
- 3.2¢/kWh-wind (central value)
- 0.7-10¢/kWh-wind (total range)

Wind Vision Scenario Provides Additional Health and Environmental Benefits

Wind Vision yields potential reductions in SO_2, NO_x, $PM_{2.5}$, creating benefits estimated using multiple methods

Majority of benefits derive from reductions in SO_2, resulting in lower concentrations of sulfate particulates; vast majority of benefits are located in Eastern U.S., and come from human health, especially reduced premature mortality

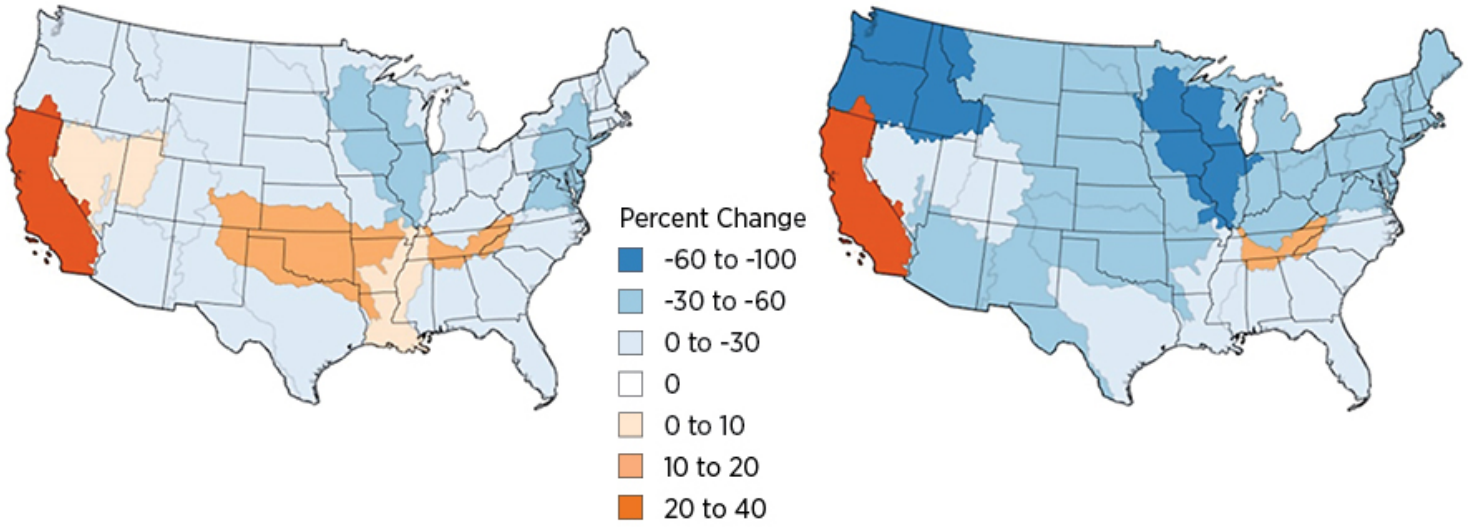




Air pollution benefits are equivalent to:

- 0.4-2.2¢/kWh-wind

Wind Vision Reduces Water Use in Key Watersheds Relative to No New Wind



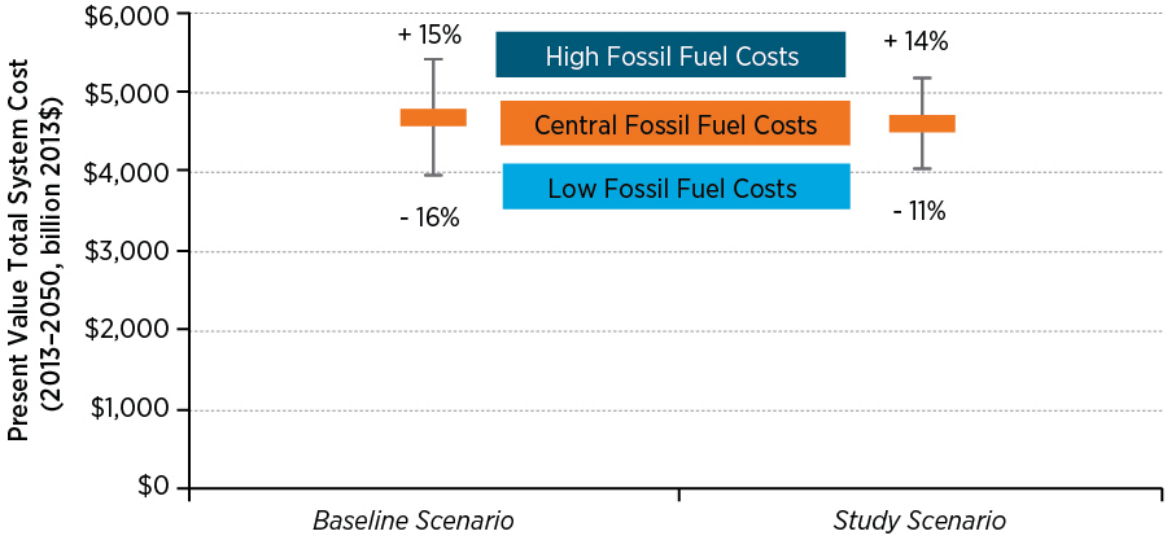
Baseline Scenario (2012–2050)

Study Scenario (2012–2050)

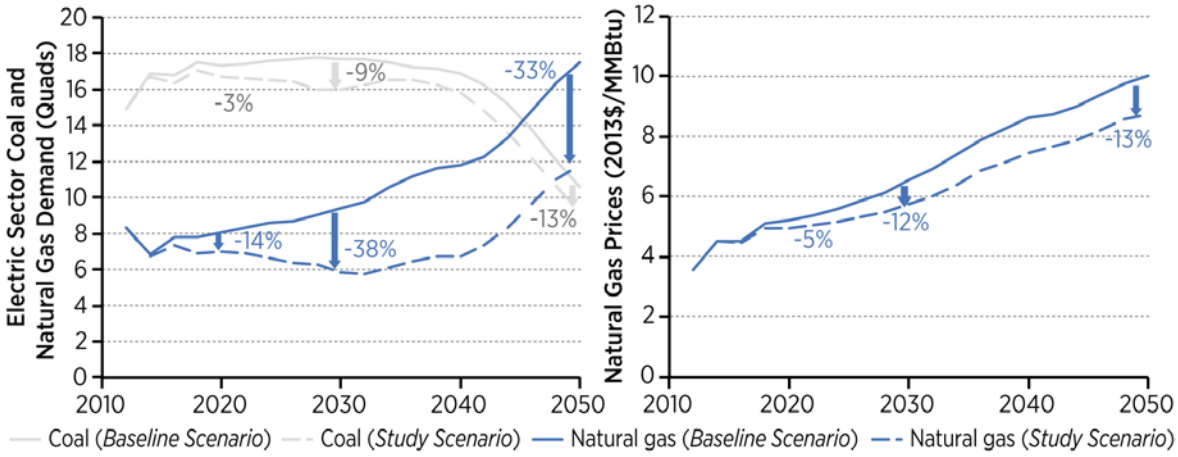
Power-sector water consumption in the Wind Vision scenario declines by 2050 in 16 of 18 watershed regions (more so than under the No New Wind scenario)

Wind Vision Has Impacts on Electric Sector Fuel Price Risks and Natural Gas Prices

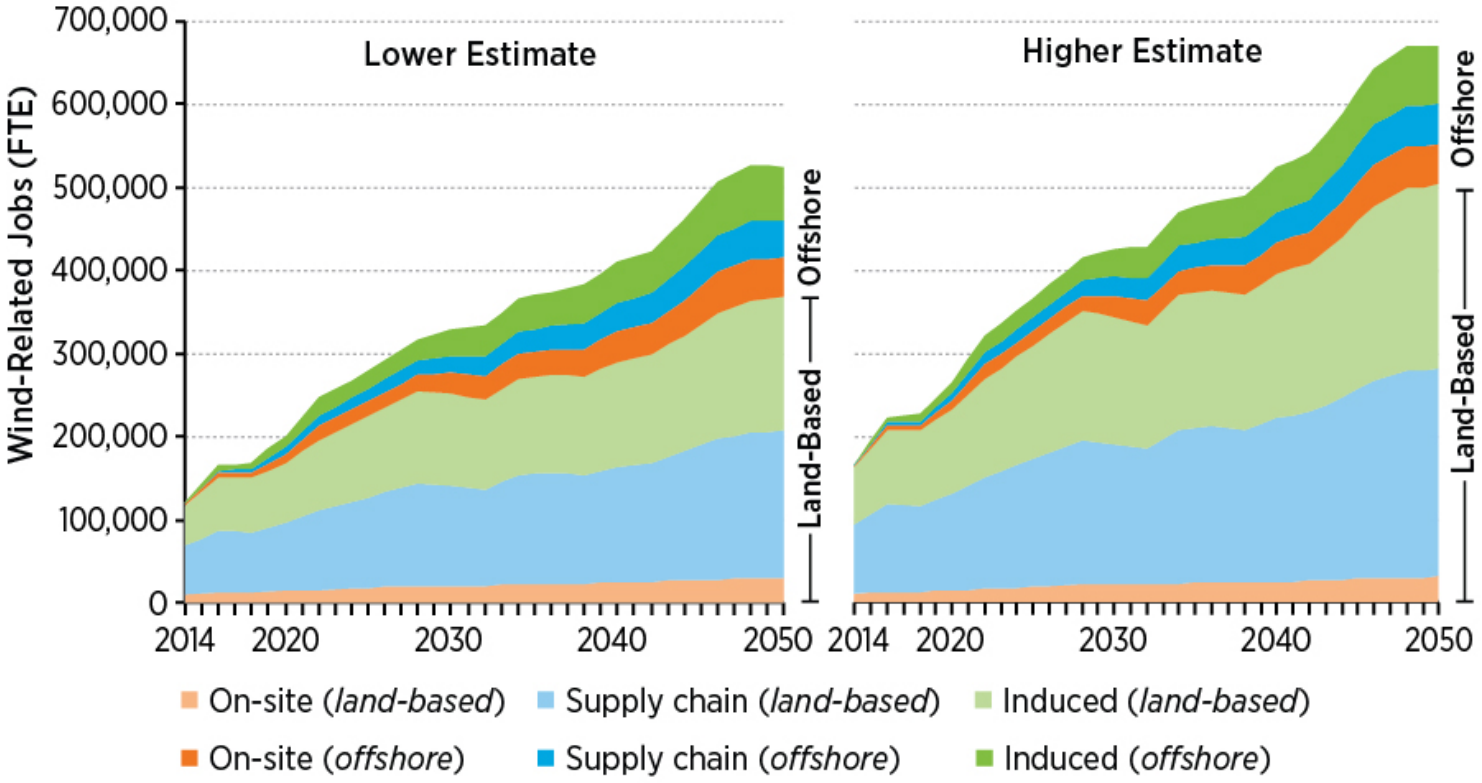
- Fuel price scenarios show that electric system costs under Wind Vision are **20% less sensitive** to long-term fluctuations in fossil fuel prices
- Lower natural gas demand in Wind Vision leads to lower gas prices; consumer benefits outside electric sector estimated at **~$280 billion**, on present value basis (associated loss by natural gas producers)



Note: Central Fossil Fuel Costs reflect the *Central Baseline Scenario and Central Study Scenario* modeling inputs; High Fossil Fuel Costs and Low Fossil Fuel Costs reflect *High and Low Fossil Fuel Cost Study* and *Baseline Scenarios*, respectively.



Wind Vision Leads to Wind-Related Jobs and Other Economic Development Impacts



Wind project development also estimated to lead to:

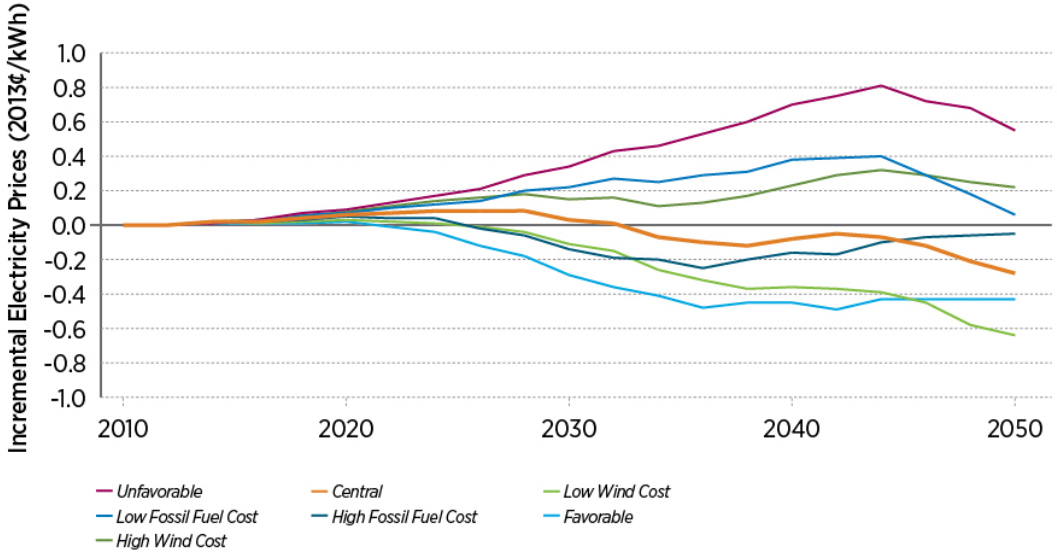
- Land-based lease payments: $350 million in 2020, $1,020 million in 2050
- Offshore lease payments: $15 million in 2020, $440 million in 2050
- Property tax payments: $900 million in 2020, $3,200 million in 2050

Wind Vision May Impose Incremental Cost and Price Impacts in Near to Medium Term

	2020	2030	2050
Central Study Scenario electricity price (change from *Baseline Scenario*)	0.06 ¢/kWh cost (+0.60%)	0.03 ¢/kWh cost (+0.30%)	0.28 ¢/kWh savings (-2.2%)
Central Study Scenario annual electricity consumer costs (change from *Baseline Scenario*)	$2.3 billion costs	$1.5 billion costs	$13.7 billion savings
Study Scenario sensitivity range (% change from *Baseline Scenario*)	+0.2% to +0.9%	-2.4% to +3.2%	-5.1% to +4.8%
Study Scenario annual electricity consumer costs range (change from *Baseline Scenario*)	$0.8 to $3.6 billion costs	$12.3 billion savings to $14.6 billion costs	$31.5 billion savings to $26.9 billion costs

Note: Expenditures in 2013$

But also yields long term savings, in Central Study Scenario, compared to No-New-Wind Baseline



Note: Incremental prices are shown relative to the associated fuel cost *Baseline Scenarios* in which installed wind capacity is fixed at 2013 levels.

Costs, Benefits and Impacts Summary

The Potential of 35% of the Country's Electricity Coming from Wind Energy by 2050

Costs	Benefits		
$	GHG	Air Pollution	H_2O
$149 Billion [3%] savings	GHG: 14% less GHG; $400 Billion savings	$ 108 Billion savings; 22,000 lives saved	260 Billion gallons [23%] less consumption

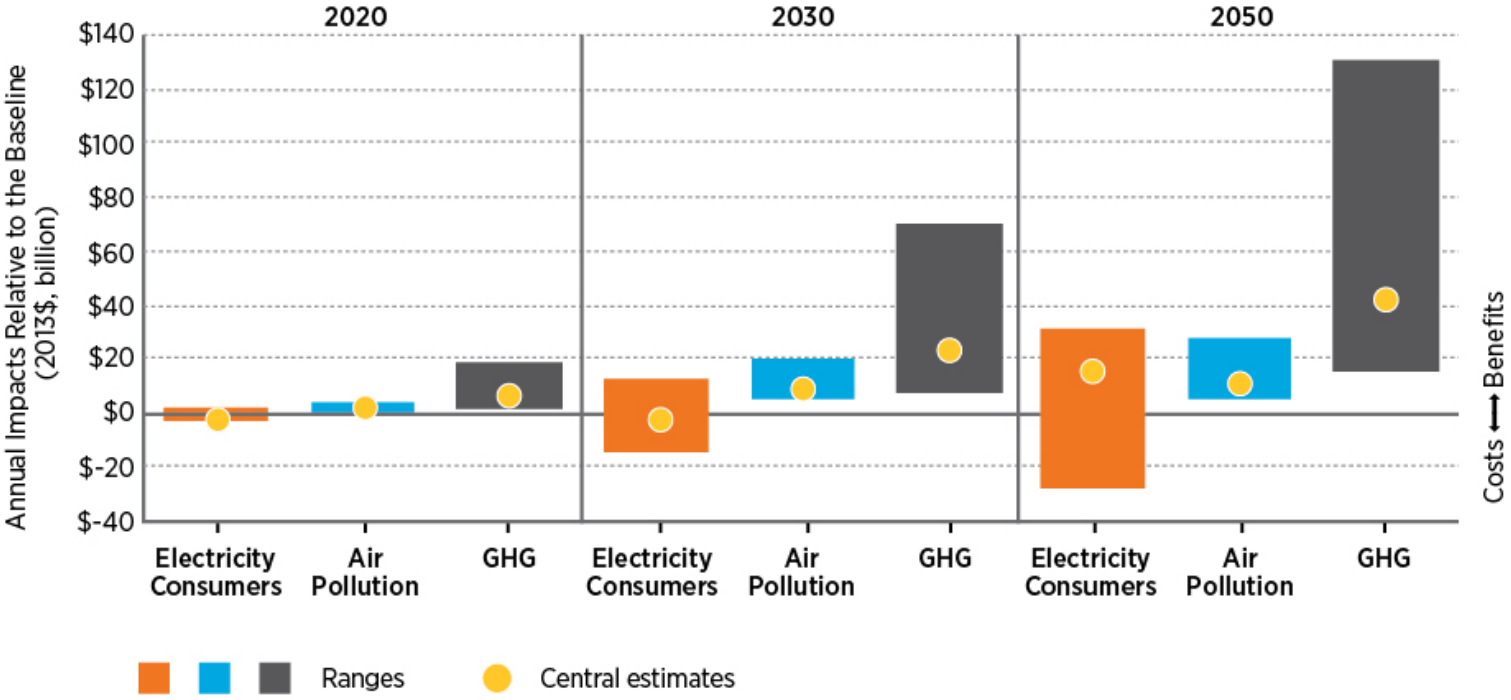
Additional Impacts

Energy Diversity	Jobs	Local Revenues	Land Use	Public Acceptance and Wildlife
Electricity prices 20% less sensitive	~ 600,000 gross jobs	$1.0 Billion/year in land leases $3.2 Billion/year in tax payments	1.5% area of contiguous US Less than 1/3 area occupied by golf courses in US today	Responsible siting; Optimizing coexistence

The Wind Vision Study Scenario results in modest increases in electricity cost in the near- and mid-term (<1% price increase), but in the long term electricity costs savings of 2% are achieved by 2050

Benefits and Costs of the Wind Vision Over Time

Reduced GHG, SO_2, NO_X, and fine particulate matter emissions provide benefits in 2020, 2030, and 2050 in addition to the savings in electricity rates achieved in the *Study Scenario* by 2050.



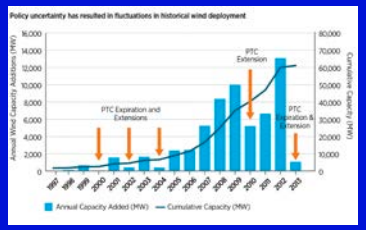
Note: Results represent the present value of incremental costs or benefits (impacts) of the *Study Scenario* relative to the *Baseline Scenario*. Central estimates are based on *Central Study Scenario* modeling assumptions. The electricity consumer costs range reflects incremental expenditures (including capital, fuel, and O&M for transmission and generation of all technologies modeled) across a series of sensitivity scenarios. Air pollution and GHG estimates are based on the *Central Study Scenario* only, with ranges derived from the methods applied and detailed in the full report.

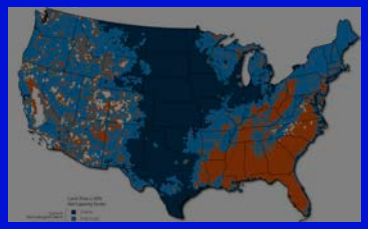
The Wind Vision Study Scenario results in modest increases in electricity cost in the near- and mid-term (<1% price increase), but in the long term electricity costs savings of 2% are achieved by 2050

Conclusions

- Modeling confirms industry forecasts of reduced annual wind capacity additions in near (2020) to mid term (to 2030) in BAU future
- Aggressive reductions in wind technology costs, increases in fossil fuel prices, and/or policy action are needed to yield deployment consistent with Wind Vision Study scenario in 2020 and 2030 timeframe
- Electric systems impacts, including grid integration and transmission challenges are surmountable
- Increased electric system costs in 2020 and 2030 timeframe to achieve Wind Vision are offset by GHG, air pollution and other benefits; after 2030, wind likely to be economically attractive even without considering those benefits

Discussion Topics





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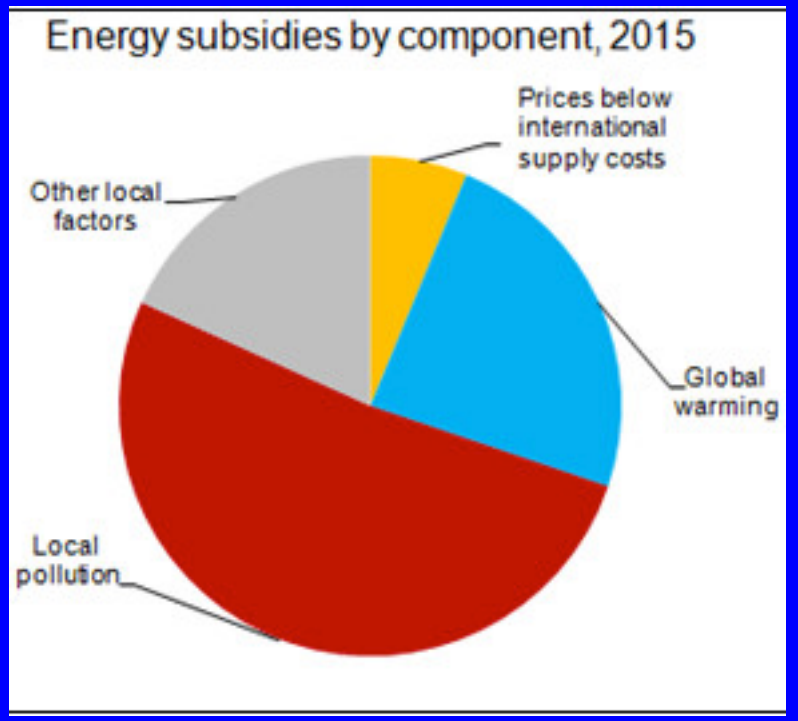
All Societies Subsidize Energy

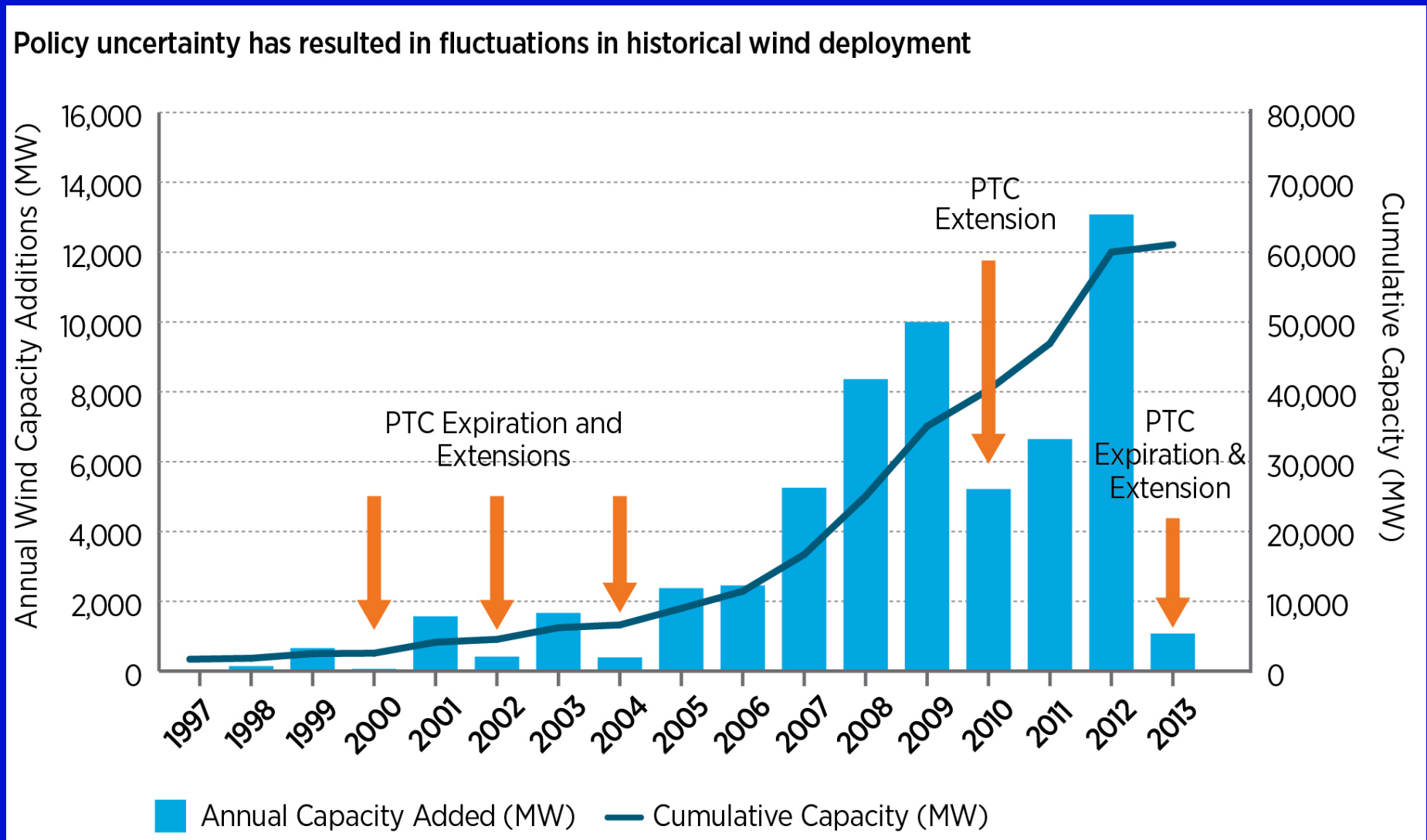
- **Fact**: All energy sources get public subsidies – generally through the tax code
- **Fact**: Wind's growth over the past 15 years has benefited from a production tax incentive
- **Fact**: Fossil fuels (oil, gas, coal) have benefited from subsidies for nearly 100 years – many are in the permanent tax code
- **Fact**: The fossil fuel industry is fighting tooth and nail to eliminate the wind incentive while maintaining their own incentives

International Monetary Fund (IMF) Findings Issued May 2015

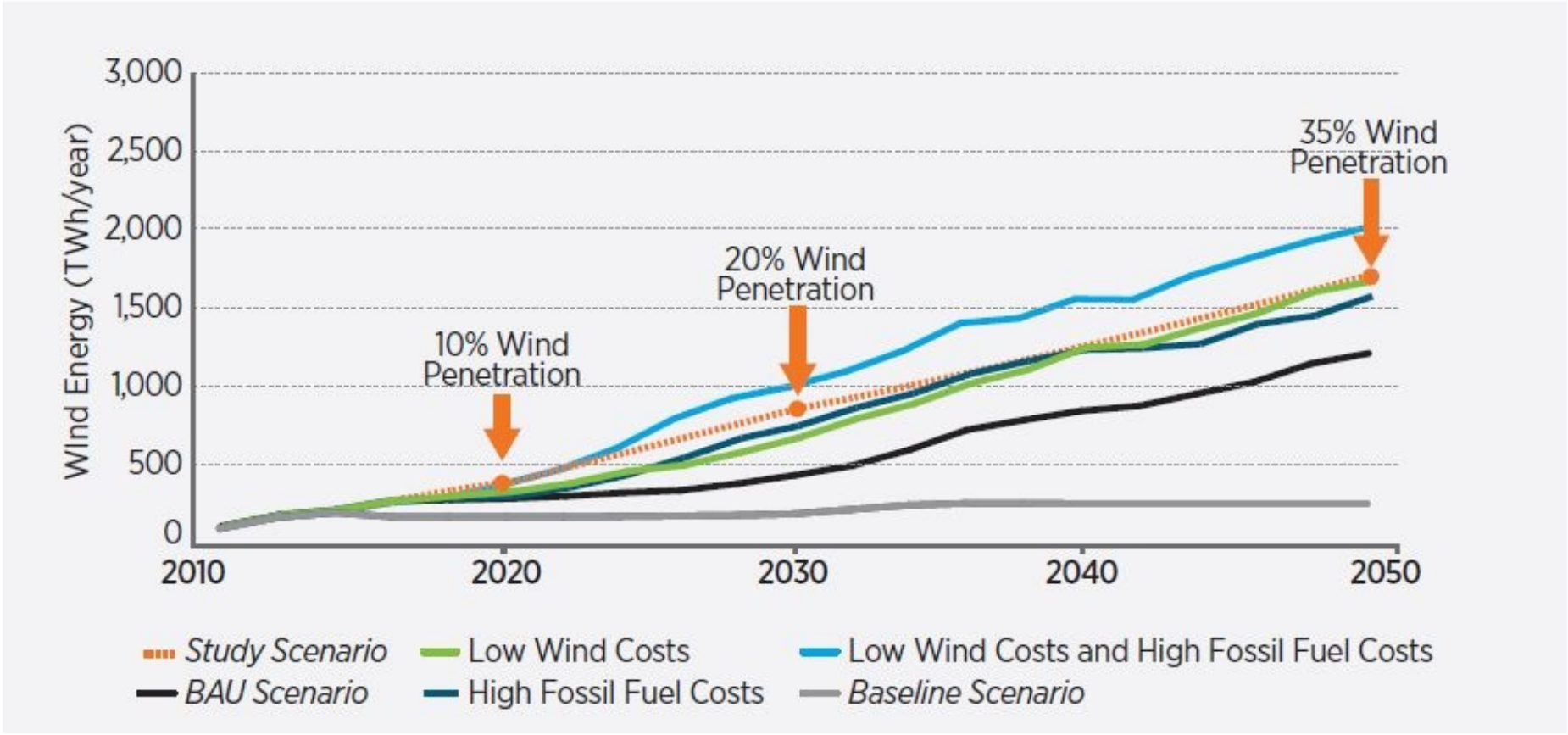
- 2015 energy subsidies worldwide: $5.3 trillion
  - China: $2.3 trillion
  - U.S.: $670 billion
- Huge majority stems from public-health and environmental damages paid for by society rather than the polluters
- Eliminating these subsidies would reduce premature deaths from air pollution, estimated at 3.7 million in 2012 by the World Health Organization -- by 55%.



Historical Policy Impacts on Wind



Wind Vision Sensitivity Scenarios

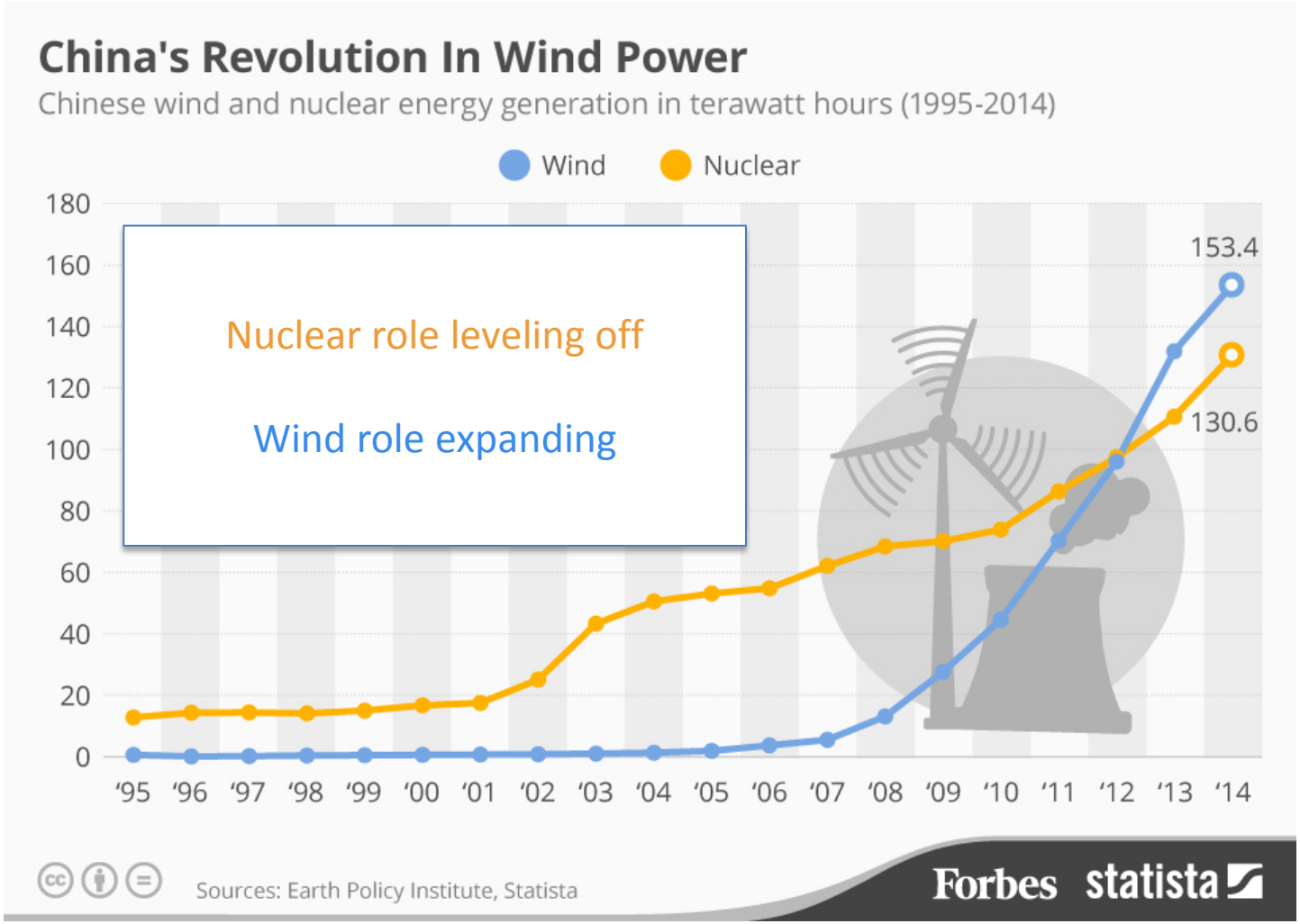


With Business as Usual (BAU – no incentives), wind deployment is minimal for the next 10 to 15 years.

Impact of Wind Incentive Uncertainty

- Extensive analysis shows that, without policy support, wind growth in the United States stagnates until the late 2020s
- The U.S. wind manufacturing and supply sector likely shrinks substantially
- Wind expansion continues unabated in countries with stable policy support for clean energy (China, Europe)
- Robust U.S. expansion resumes in the late 2020s
- Where will we get our wind equipment?

Wind and Nuclear Generation in China



China 2050 High Renewable Energy Penetration Scenario and Roadmap Study*

2050 power generation:15,200 TWh

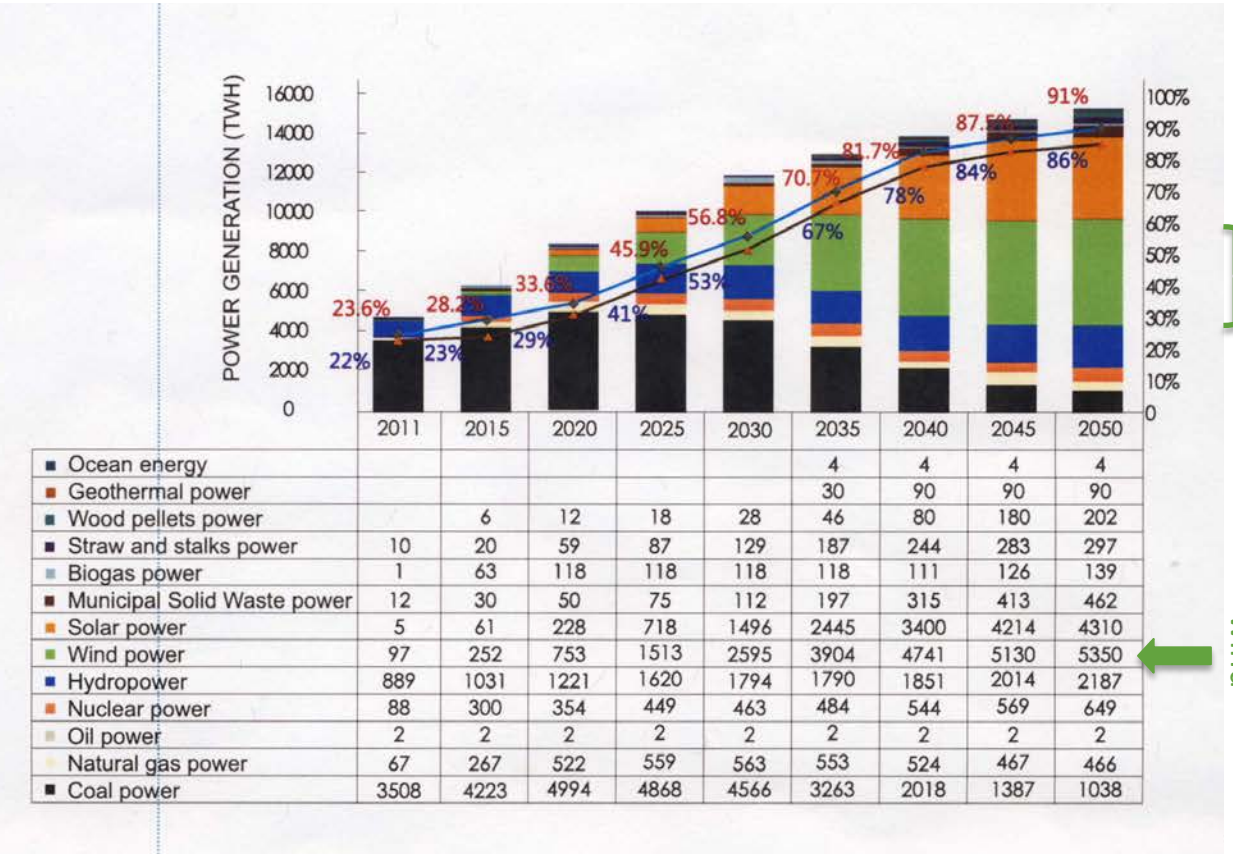
91% non-fossil

86% renewable

35% wind

28% solar

7% coal

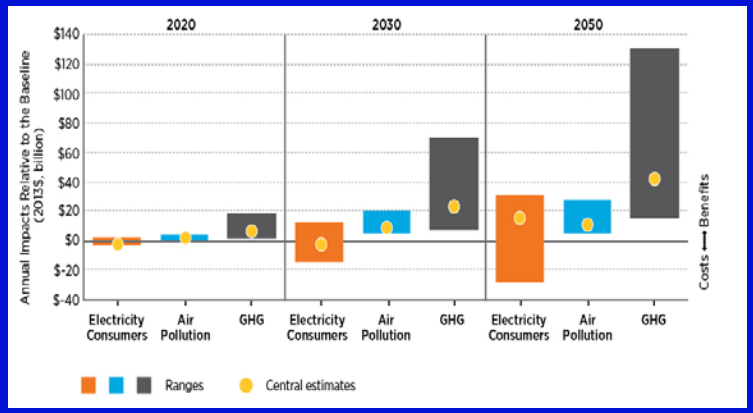


	2011	2015	2020	2025	2030	2035	2040	2045	2050
Ocean energy						4	4	4	4
Geothermal power						30	90	90	90
Wood pellets power		6	12	18	28	46	80	180	202
Straw and stalks power	10	20	59	87	129	187	244	283	297
Biogas power	1	63	118	118	118	118	111	126	139
Municipal Solid Waste power	12	30	50	75	112	197	315	413	462
Solar power	5	61	228	718	1496	2445	3400	4214	4310
Wind power	97	252	753	1513	2595	3904	4741	5130	5350
Hydropower	889	1031	1221	1620	1794	1790	1851	2014	2187
Nuclear power	88	300	354	449	463	484	544	569	649
Oil power	2	2	2	2	2	2	2	2	2
Natural gas power	67	267	522	559	563	553	524	467	466
Coal power	3508	4223	4994	4868	4566	3263	2018	1387	1038

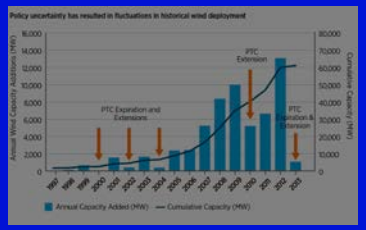
*Energy Research Institute (China), National Development and Reform Commission, April 2015

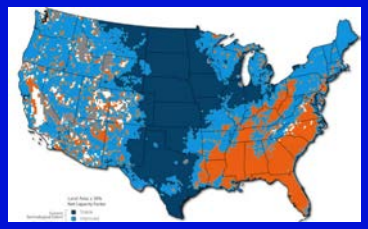
Implications for Policy Makers

- Without near-term policy support, wind deployment will be minimal and the domestic wind manufacturing sector will likely wither
- Wind's environmental benefits would more than offset any near term incremental costs, providing justification for policy support
- Prospective sources of support:
  - PTC
  - EPA Clean Power Plan
  - Other?



Discussion Topics





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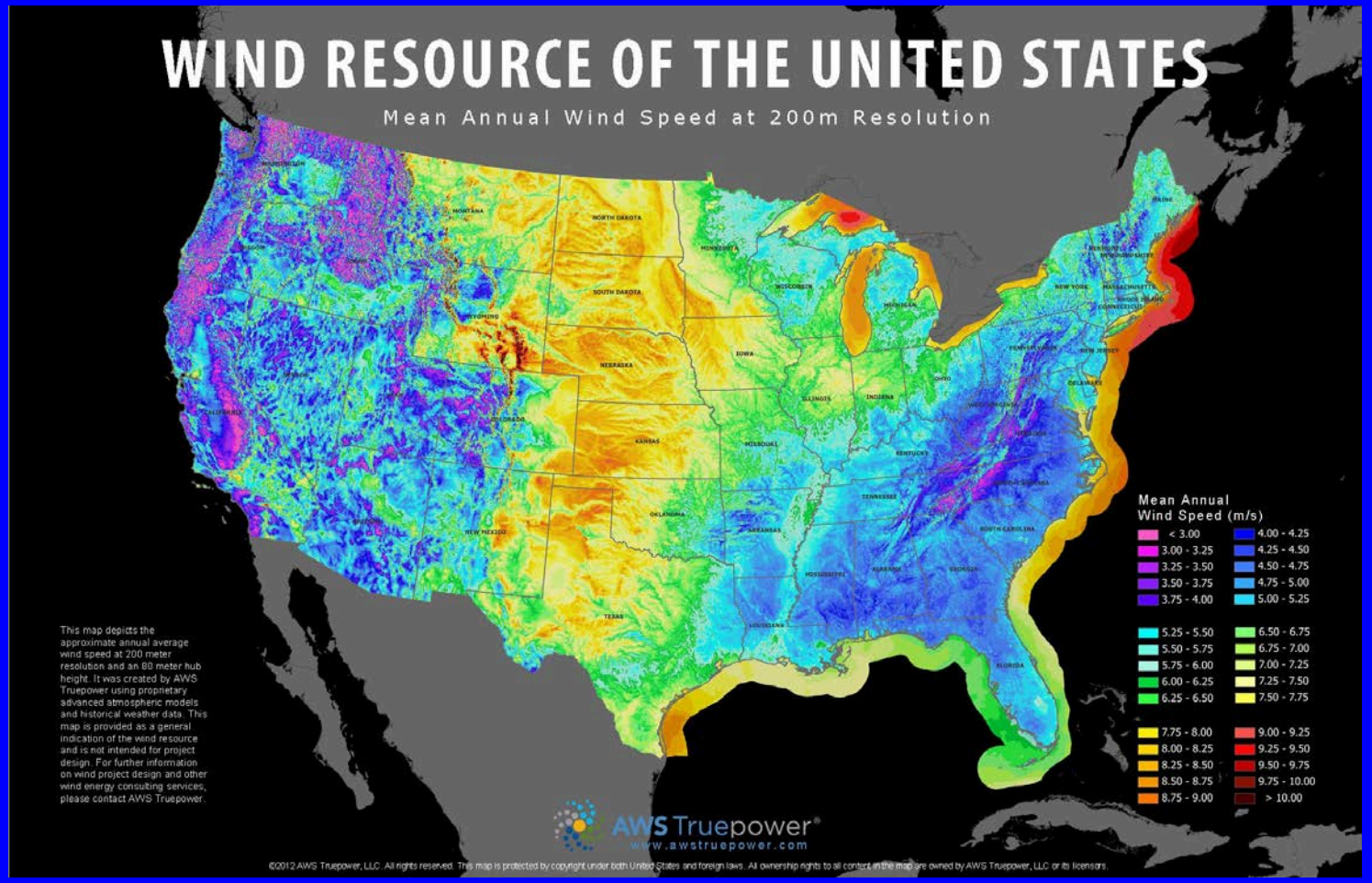
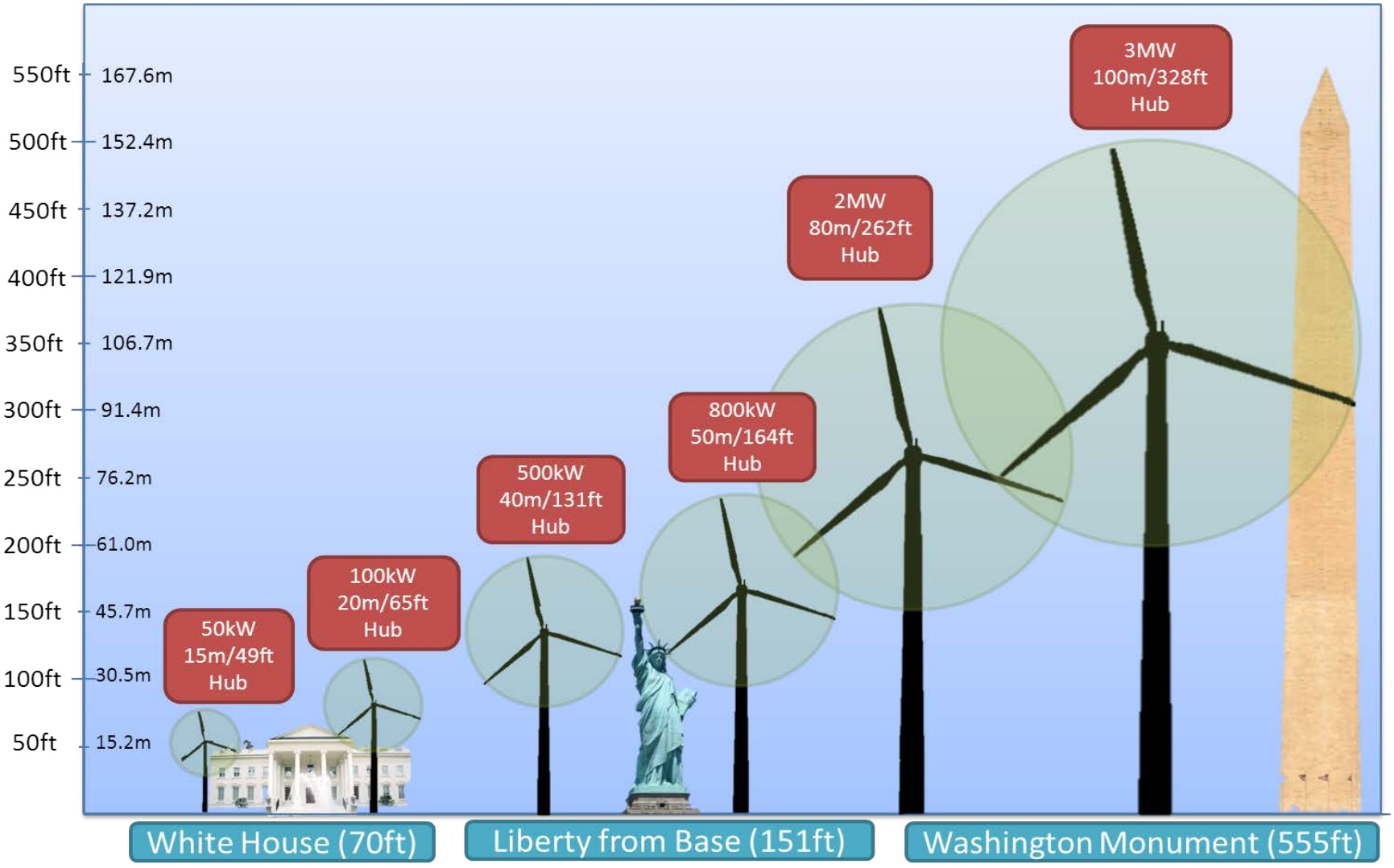
What's the Size of the U.S. Wind Resource?



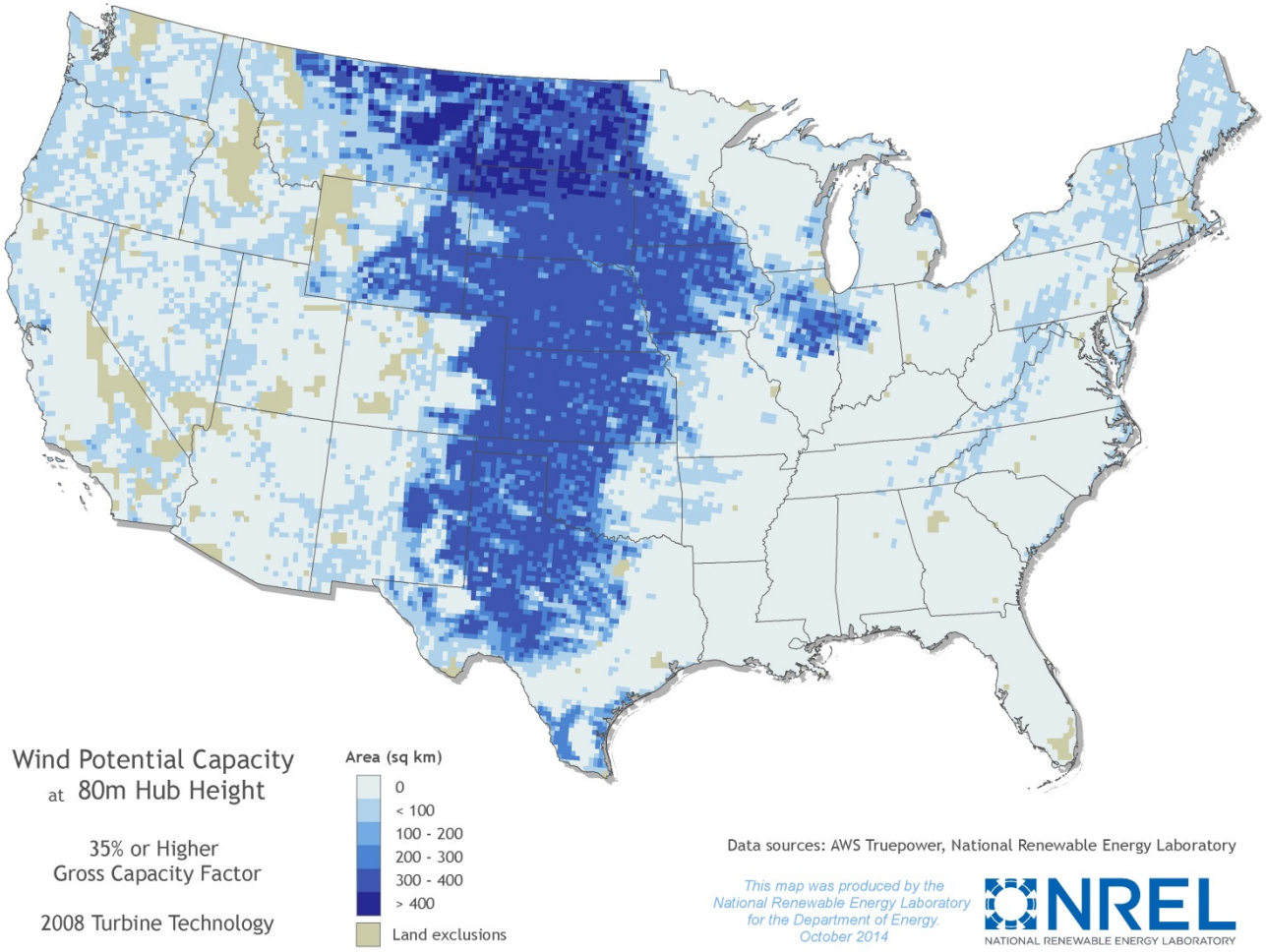
Authoritative Estimate: Developable wind resource is 13 times ***total*** U.S. electricity consumption

Evolution of Wind Turbine Size (Land Based)



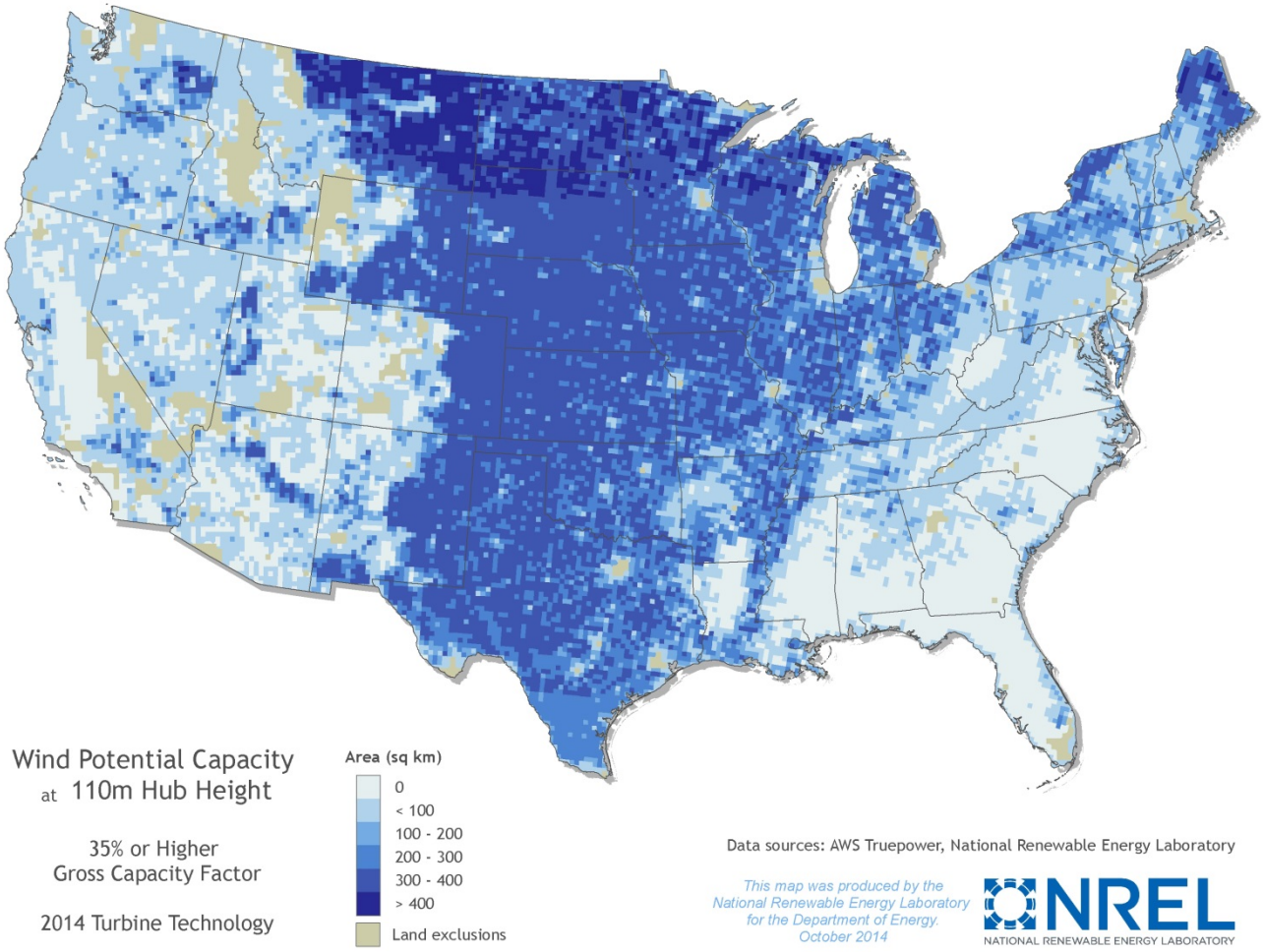
Yesterday's Technology
Estimates of Economically Viable Development

Land area with a gross CF > 35% for a 2008 IEC Class 2 turbine at an 80 m hub height: 634,475 mi^2 above 35% GCF



Today's Technology
Estimates of Economically Viable Development

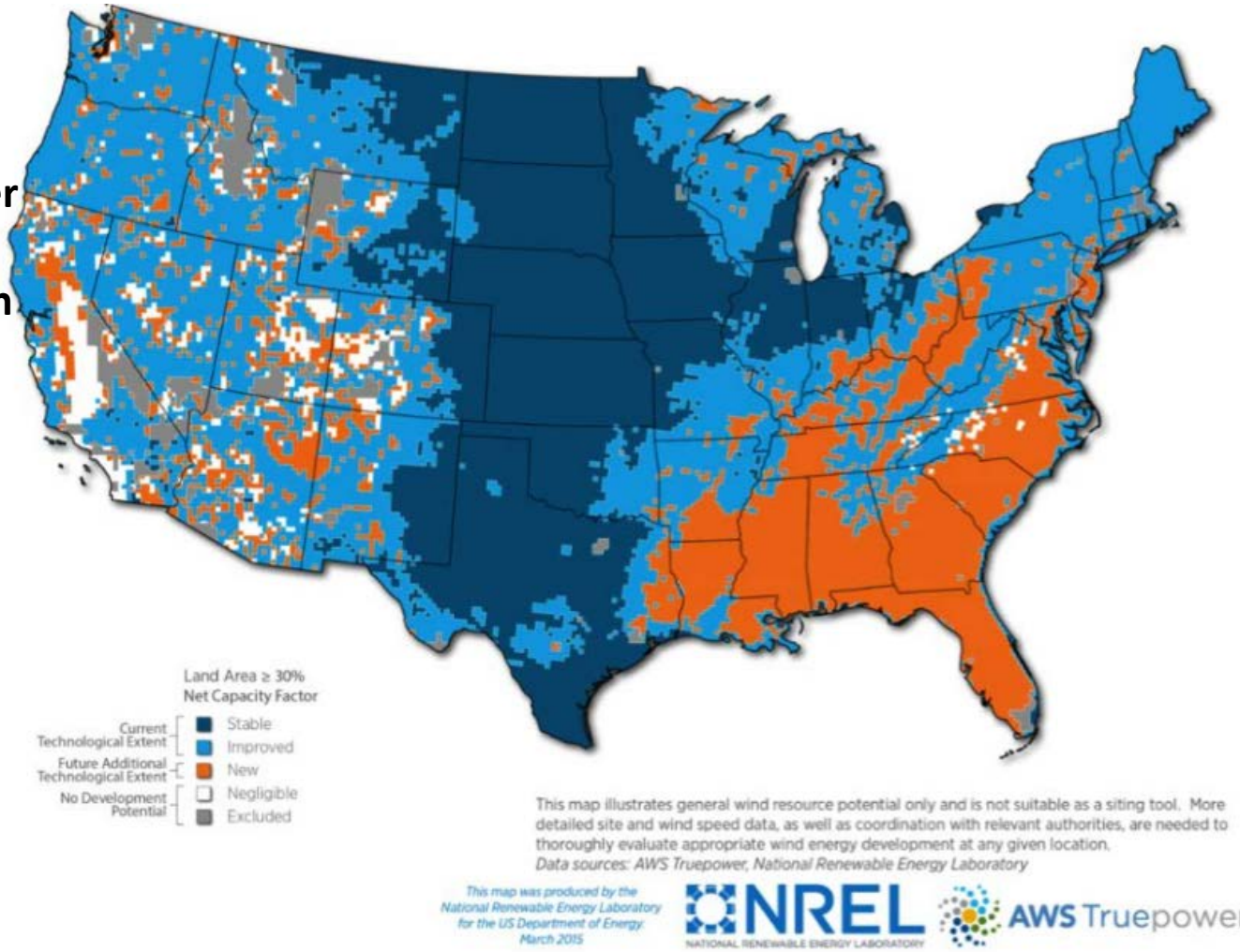
Land area with a gross CF > 35% for IEC class appropriate GE turbine at an 110 m hub height: 1.3 million mi^2 above 35% GCF



New Opportunities for Wind

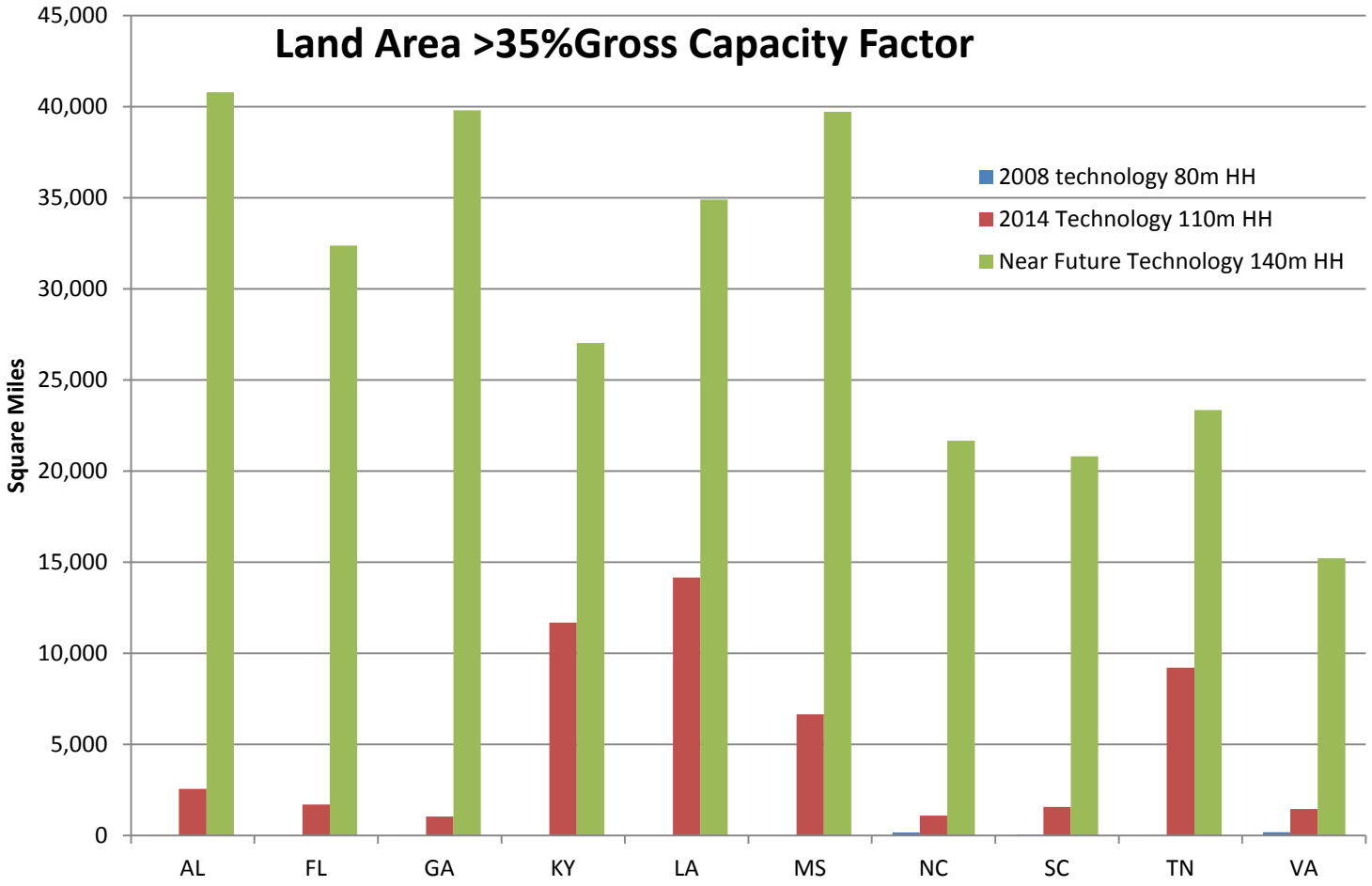
Larger rotor designs and a 140 m hub height provide the opportunity for wind power to expand to all U.S. states.

Next generation wind turbines will unlock additional wind power resource potential across over 1.1 million square miles, nearly tripling the amount of developable land area for wind when compared with 2008 turbine technology;



Expanded Regional Potential

New technology allows greatly expanded development potential in areas where limited potential was thought to exist



Wind Vision

http://energy.gov/eere/wind/wind-vision

Enabling Wind Power Nationwide

http://energy.gov/eere/wind/downloads/enabling-wind-power-nationwide