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Wind Vision:

A New Era for Wind Power in the United States

Analysis Highlights and Key Results

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Presentation Overview

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- Analysis Objectives and Scenario Structure
- Wind Deployment and Related Electric Sector Impacts
- Transmission and Integration Impacts
- Scenario Costs and Electricity Price Implications
- Scenario Benefits and Other Impacts

Wind Vision: Analysis Objectives

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- Analyze the **economic competitiveness of wind energy** across multiple sensitivities: near-(2020), mid-(2030), long-term(2050)

- Analyze a credible wind energy scenario to quantify effects on: **the wind industry, the electric sector, transmission and integration, costs and prices, and benefits and impacts**

- **Inform priorities** for public sector research and other stakeholders

"Bottom-up" Modeling Suggest Possibilities for Wind but Growth Stagnates under BAU

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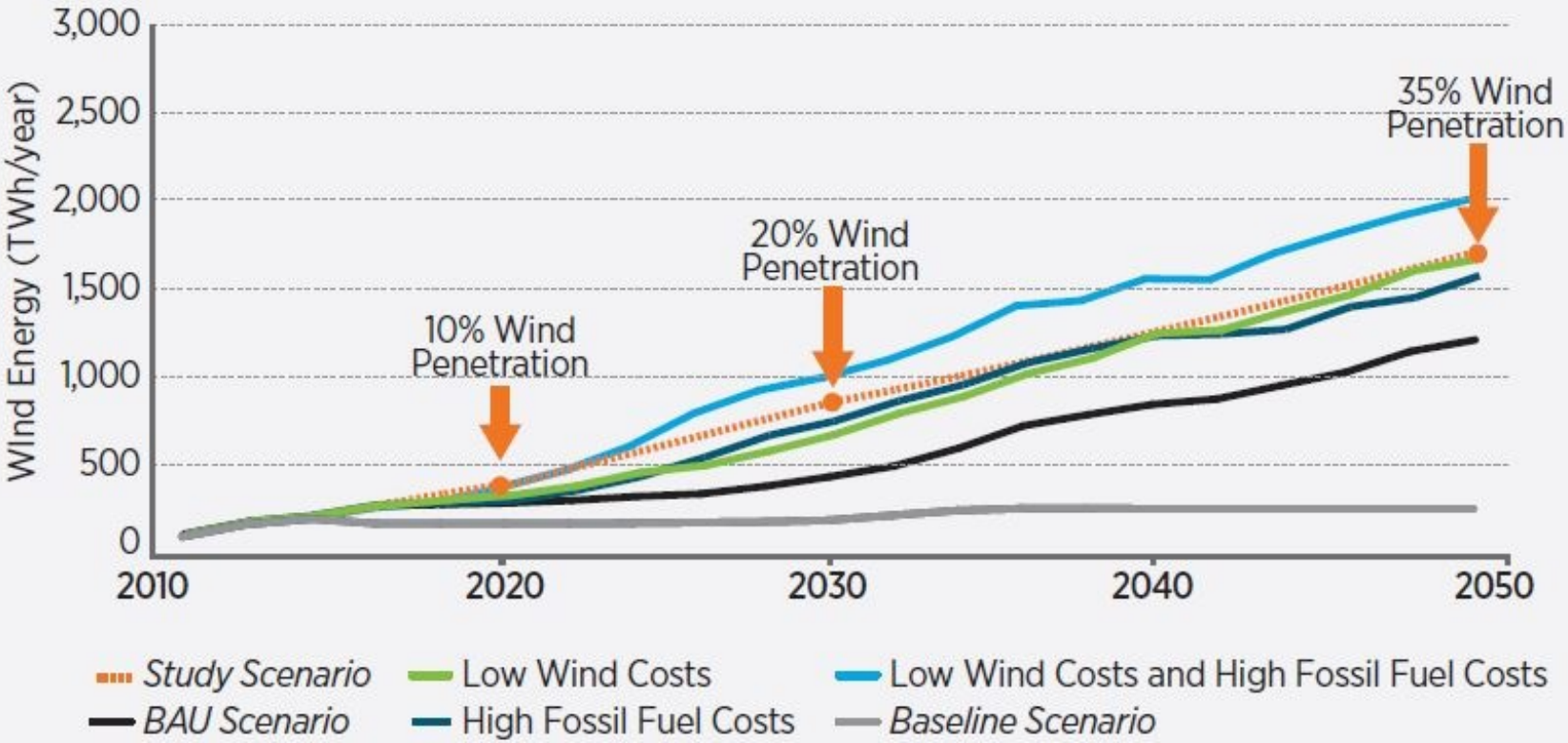
Selected Bottom-Up Sensitivities and the *Study Scenario*



The Study Scenario was informed by "bottom up" economic modeling results, recent industry deployment trends and domestic manufacturing capacity, and the broader literature

The Wind Vision Scenario Structure

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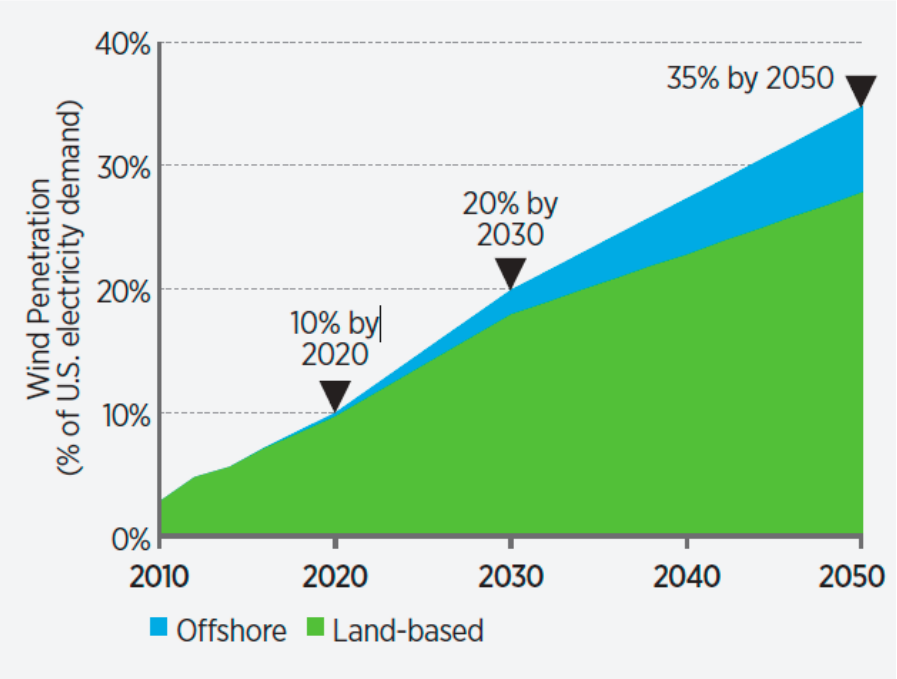
- The *Study Scenario* is inclusive of land-based, offshore, and distributed wind technologies; however, distributed wind is not explicitly modeled or quantitatively assessed
- Analysis assumes policy as written today (e.g., RPS remains as is; PTC is expired)
- The *Study Scenario* is policy agnostic: does not explicitly evaluate or consider policy options
- Impacts are estimated relative to the No-New-Wind *Baseline Scenario*; provides insights on impact from all future wind additions



Key Questions:

1. **What are the impacts to the wind industry and electric sector generally, from this scenario?**
2. **What are the costs, benefits, and other impacts that result from this scenario?**

The Wind Vision *Study Scenario* Reaches ~400 GW of Wind by 2050

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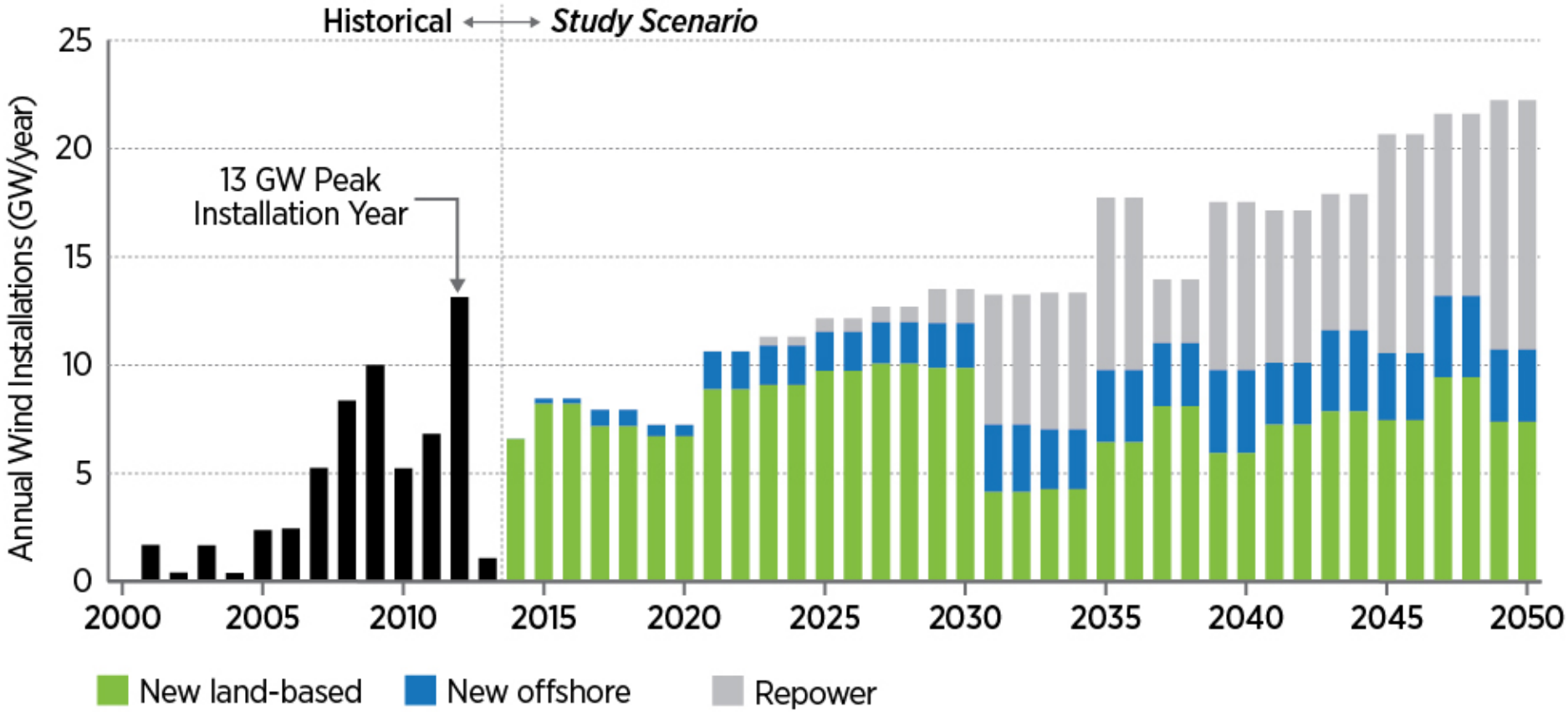

Note: New capacity installations include capacity added at a new location to increase the total cumulative installed capacity or to replace retiring capacity elsewhere. Repowered capacity reflects turbine replacements occurring after plants reach their useful lifetime. Wind installations shown here are based on model outcomes for the *Central Study Scenario* and do not represent projected demand for wind capacity. Levels of wind capacity to achieve the penetration trajectory in the *Study Scenario* will be affected by future advancements in wind turbine technology, the quality of the wind resource where projects are located, and market conditions, among other factors.

The *Study Scenario* Results in Broad Geographic Distribution of Wind Capacity

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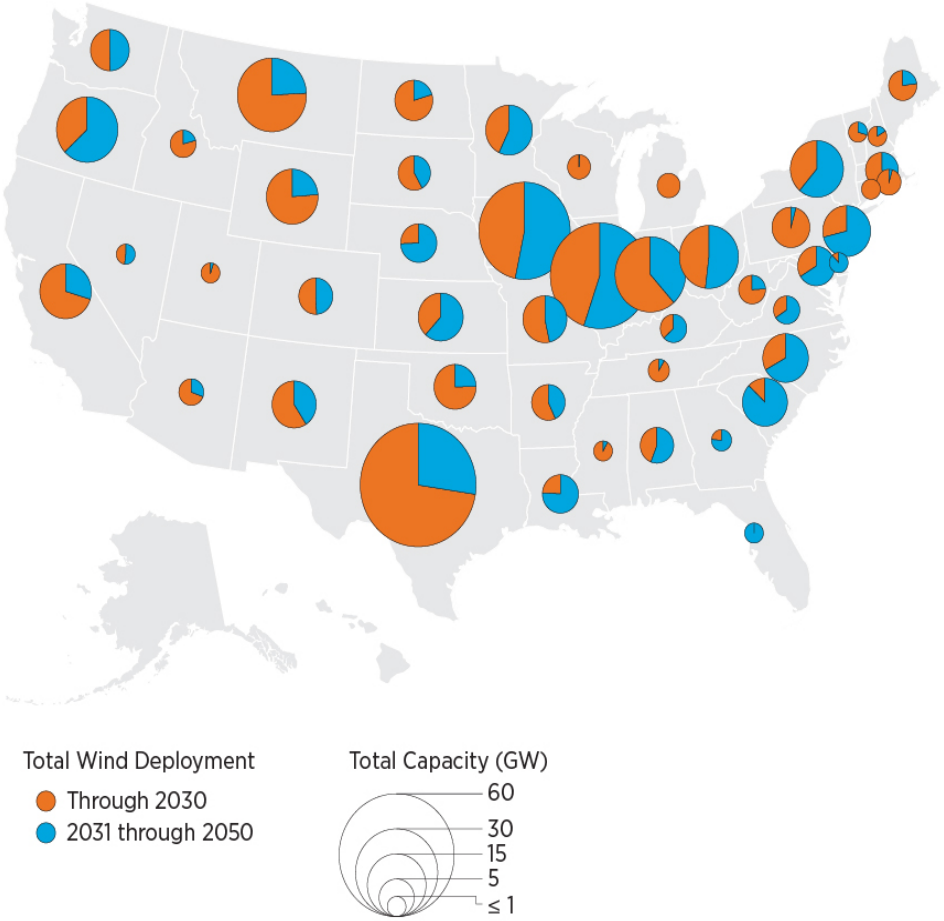
Combined Land-based & Offshore Wind Capacity



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 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 uncertain future conditions (e.g. fuel prices, legislation, incentives, access to transmission, permitting)

The *Study Scenario* Drives Significant Changes in the Electric Sector

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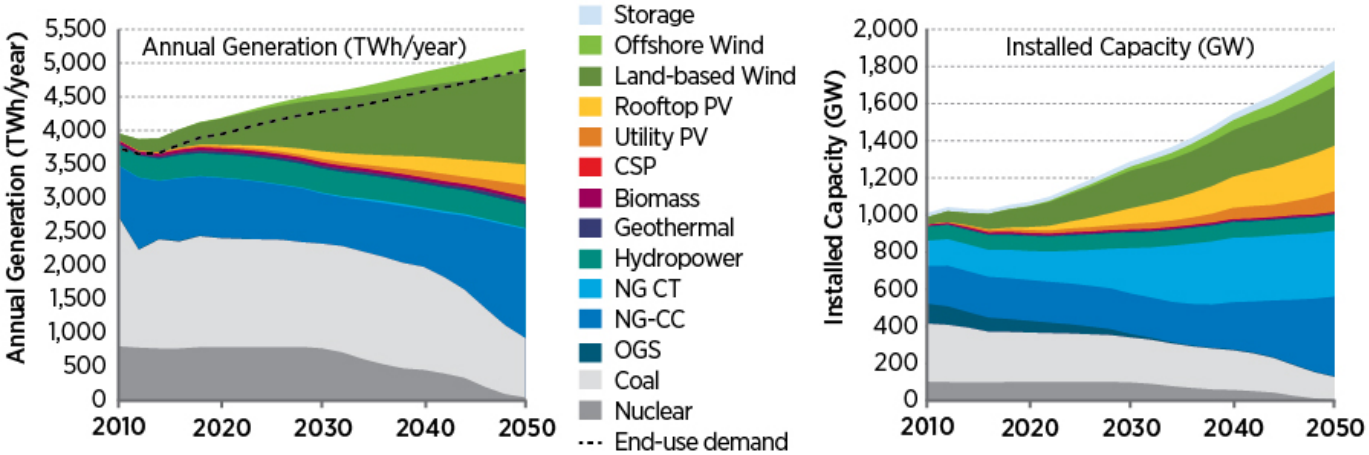
Wind Vision Central Study Scenario



Note: Total generation exceeds end-use demand due to transmission and distribution losses. Technology category acronyms: PV = photovoltaic, CSP = concentrating solar power (with and without thermal energy storage), NGCT = natural gas-fired combustion turbines, NGCC = natural gas-fired combined cycle, OGS = oil and gas steam turbines. Biomass includes dedicated biopower, co-fired biomass with coal, and landfill gas or municipal solid waste capacity; hydropower includes all net Canadian imports.

- In 2013, wind was the 5th largest contributor to the electricity mix; under the *Central Study Scenario*, wind becomes the 2nd largest in 2030 and single largest in 2050
- For the *Study Scenario,* the growth in wind generation generally exceeds the rate of electricity load growth resulting in reductions in aggregate generation from other sources
- The diminished role for coal and nuclear is a function of age-based retirements as well as the relative cost of new plants and occurs in both the *Study Scenario* and *Baseline*
- *Note: Uncertainty increases with time*

In the *Study Scenario,* Wind Energy Tends to Displace Natural Gas Generation

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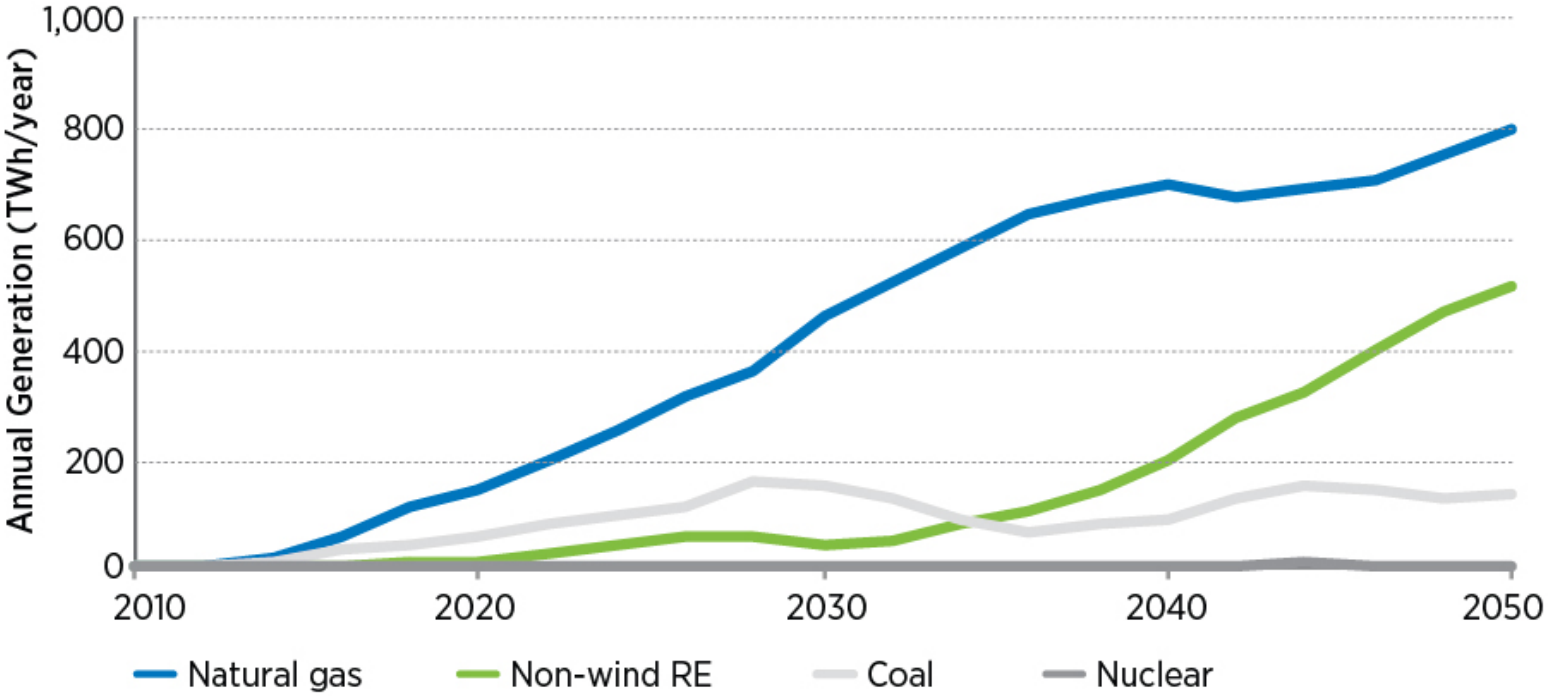

Note: The positive values indicate there was greater generation from these sources under the *Baseline Scenario* compared with the *Study Scenario*. The "natural gas" category includes oil-fired generation. Non-wind RE refers to non-wind renewable energy.

- Wind primarily displaces fossil fuel-based generation (particularly natural gas) through all years (~600 TWh avoided fossil fuel-based generation in 2030, over 900 TWh in 2050)
- Displacement of non-fossil-based generation is small in the near- and mid-term, but grows in the 2030 – 2050 timeframe

Transmission Needs Are Non-trivial but Are Generally Deemed Manageable

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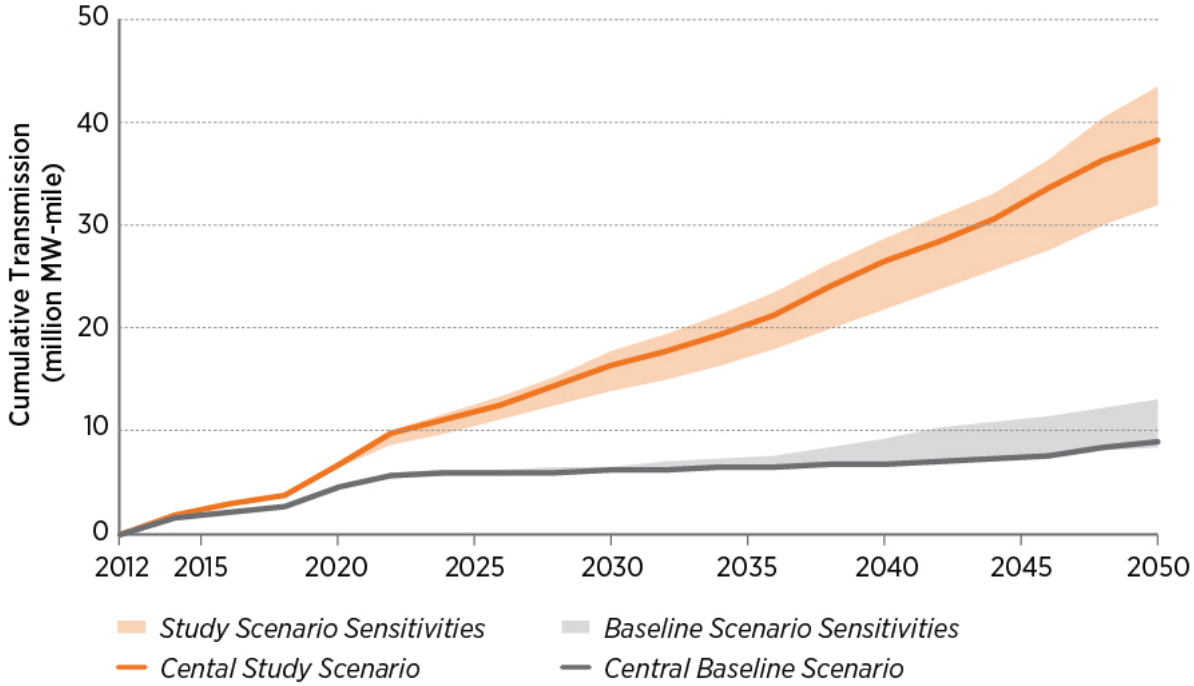

Note: Figure depicts cumulative transmission measured from 2013 up to the x-axis year.

- Cumulative transmission need of 2 million MW-miles by 2020, 10 million MW-miles by 2030, and 29 million MW-miles by 2050 for *Study Scenario* relative to *Baseline Scenario*
- 2013-2050 incremental transmission needed to achieve the *Study Scenario* is less than 20% of the roughly 200 million MW-miles that exist today
- NPV (2013-50) of incremental transmission expenditures total $60B or 0.5¢/kWh-wind

Regional Wind Penetration Drives Integration and Transmission Needs

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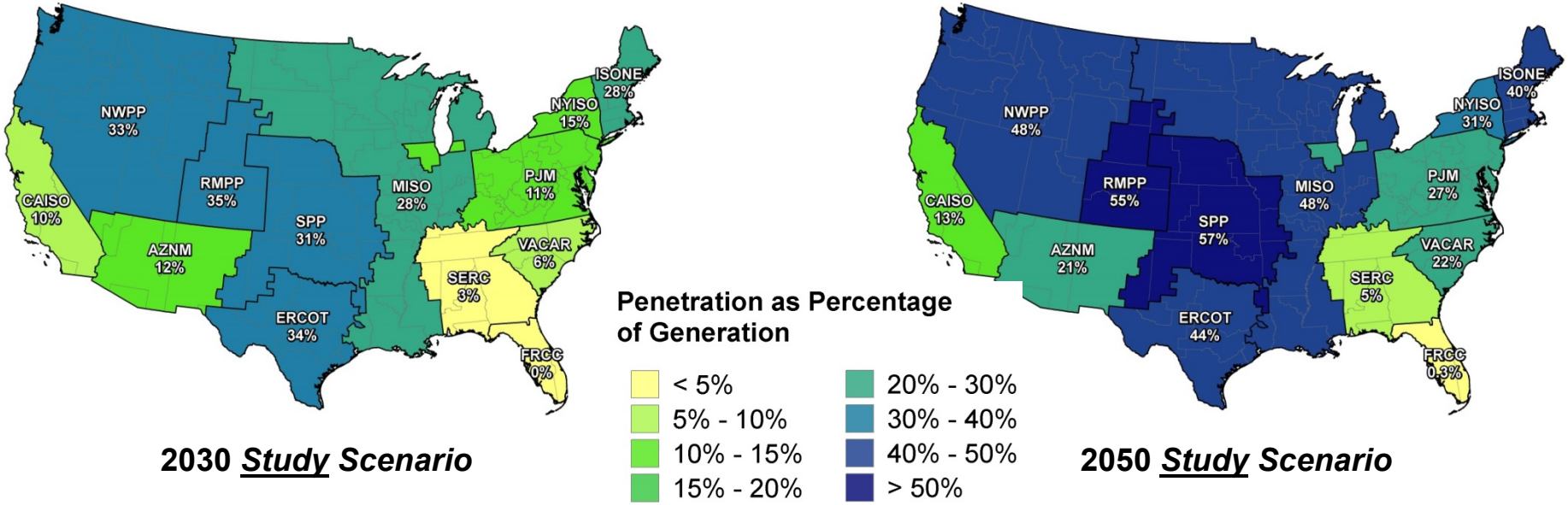

2030 *Study* Scenario

2050 *Study* Scenario

Note: Wind penetration displayed is with respect to regional total generation.
Wind Vision targets reflect wind penetration with respect to national end-use demand

- While all regions contribute, annual wind penetration varies by region, with some exceeding 30% by 2030 and 45% by 2050, particularly for Western & Central regions
- Options to manage increased wind penetration include:
  - Market and institutional solutions (e.g. wider area coordination, faster commitment and dispatch schedules)
  - Operational practices (e.g. improved forecasting, increased dispatch flexibility, curtailments)
  - Technology solutions (e.g. storage, demand-side options, flexible generation)
  - Transmission expansion

Wind Vision: Costs, Benefits, Impacts

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Goal: Comprehensively evaluate a subset of the possible costs, benefits, and impacts of achieving the Wind Vision

COSTS

- Retail electricity prices and electric sector costs
- Local impacts: land, wildlife, aviation & radar, public acceptance, etc.

BENEFITS

- Greenhouse gas emissions reduction
- Air pollution impacts
- Water usage reduction

IMPACTS

- Energy diversity and risk reduction
- Workforce and economic development impacts

Compare core "Wind Vision *Study*" with "No-New-Wind *Baseline*" scenarios

The *Study Scenario* May Impose Incremental Cost and Price Impacts through 2030

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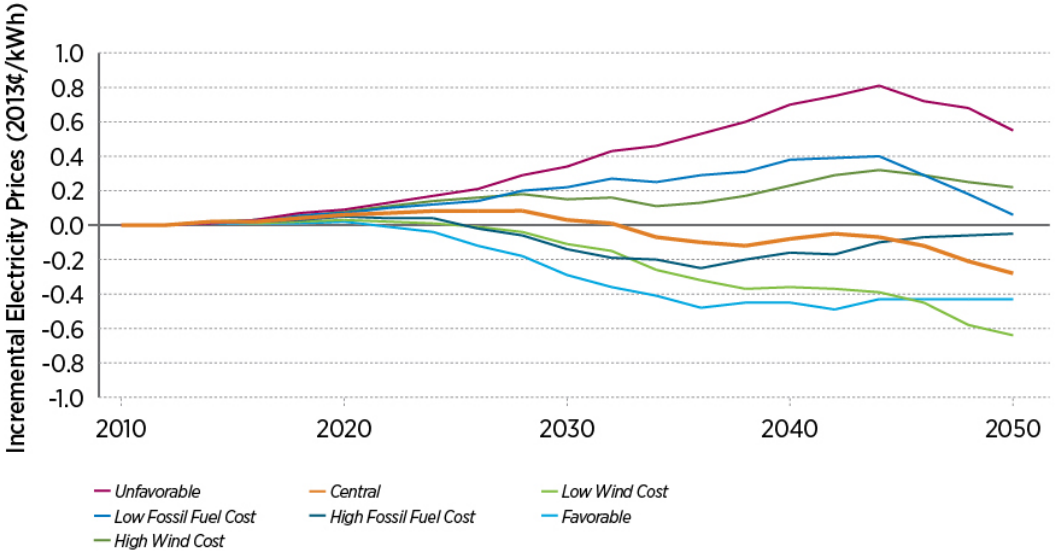
	2020	2030	2050
Central Study Scenario electricity price (change from *Baseline Scenario*)	0.06 ¢/kWh cost (+0.60%)	0.03 ¢/kWh cost (+0.30%)	0.28 ¢/kWh savings (-2.2%)
Central Study Scenario annual electricity consumer costs (change from *Baseline Scenario*)	$2.3 billion costs	$1.5 billion costs	$13.7 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.

Land and Offshore Area Requirements; Related Wildlife and Human Impacts

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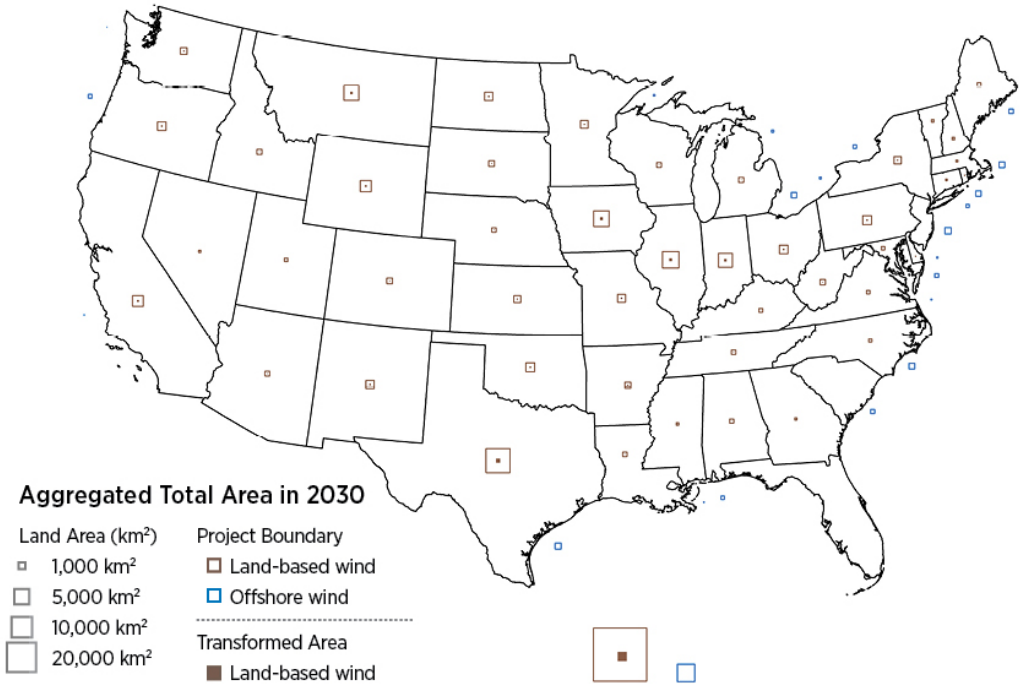

Note: project boundary estimates assume a 3 MW/km² plant density, transformed land area is assumed to be 3% of total plant area

- 67,000 km² of land and 7,300 km² of offshore area affected in 2030 under Central Study scenario; in 2050, values increase to 106,000 km² of land and 29,000 km² of offshore area
- Transformed land area (e.g. for roads, towers, electrical equipment, etc.) makes up significantly smaller fraction (~3%): 2,000 km² by 2030 and 3,200 km² by 2050
- Wind project development, as with all electric generation sources, has a wide range of unique impacts on wildlife and on humans, discussed in depth in the full report

The *Study Scenario* Reduces Damages from Global Climate Change

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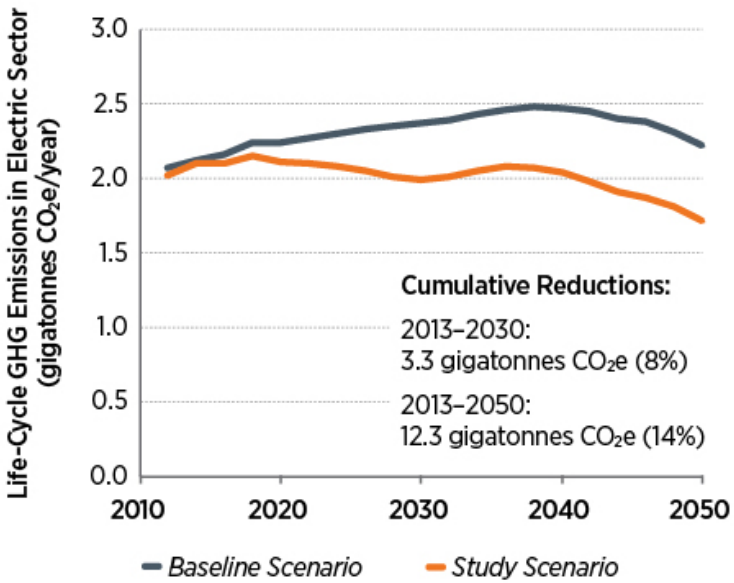
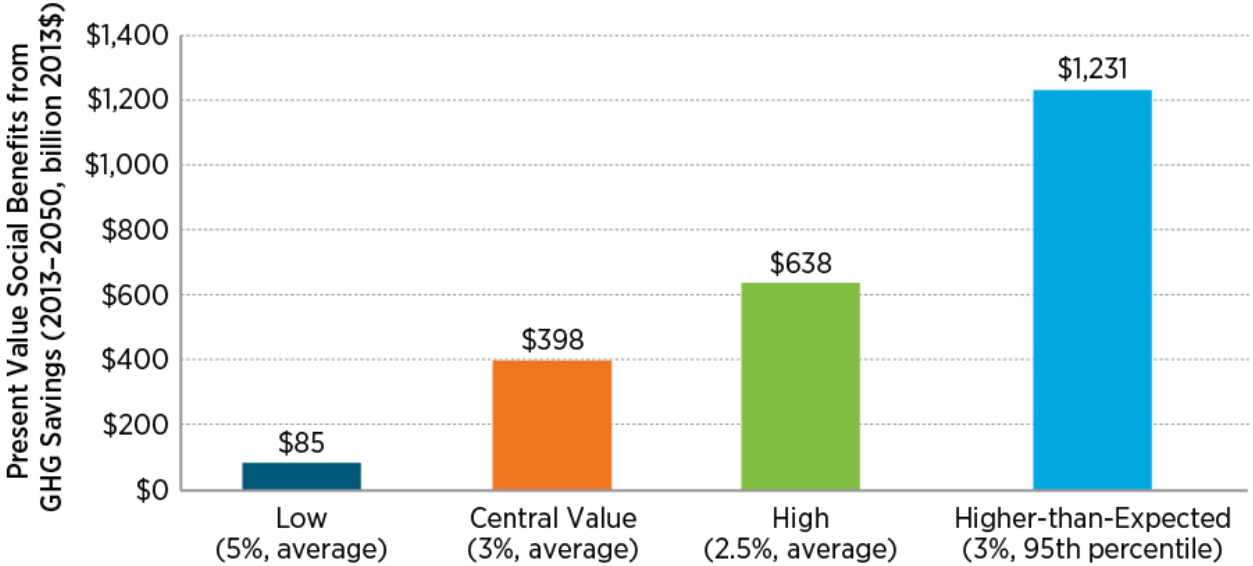
Wind Vision results in life-cycle GHG savings in U.S. power sector of **6% in 2020**, **16% in 2030** and **23% in 2050** relative to No New Wind; economic value of those reductions estimated with IWG Social Cost of Carbon





Social benefits are equivalent to:

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

The *Study Scenario* Provides Additional Health and Environmental Benefits

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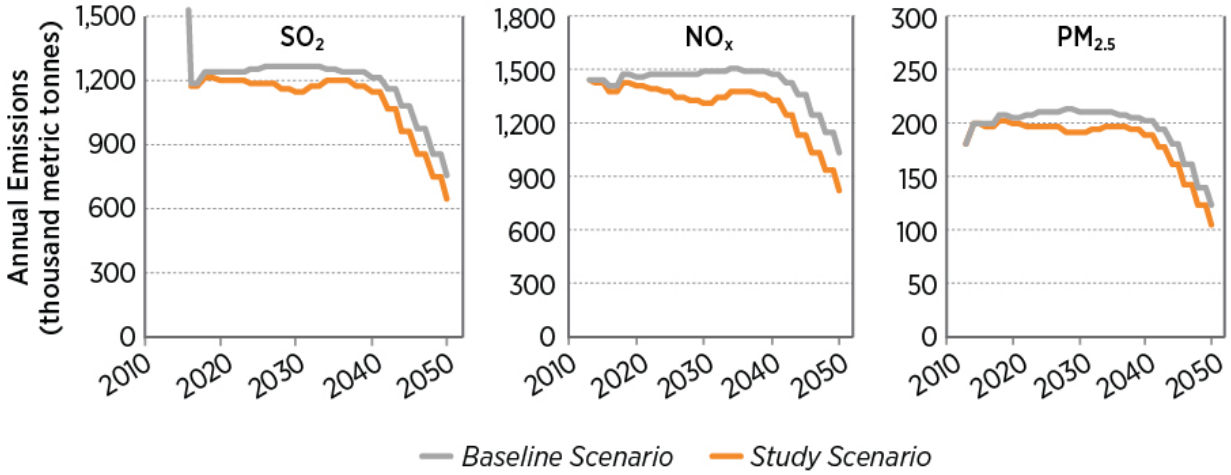
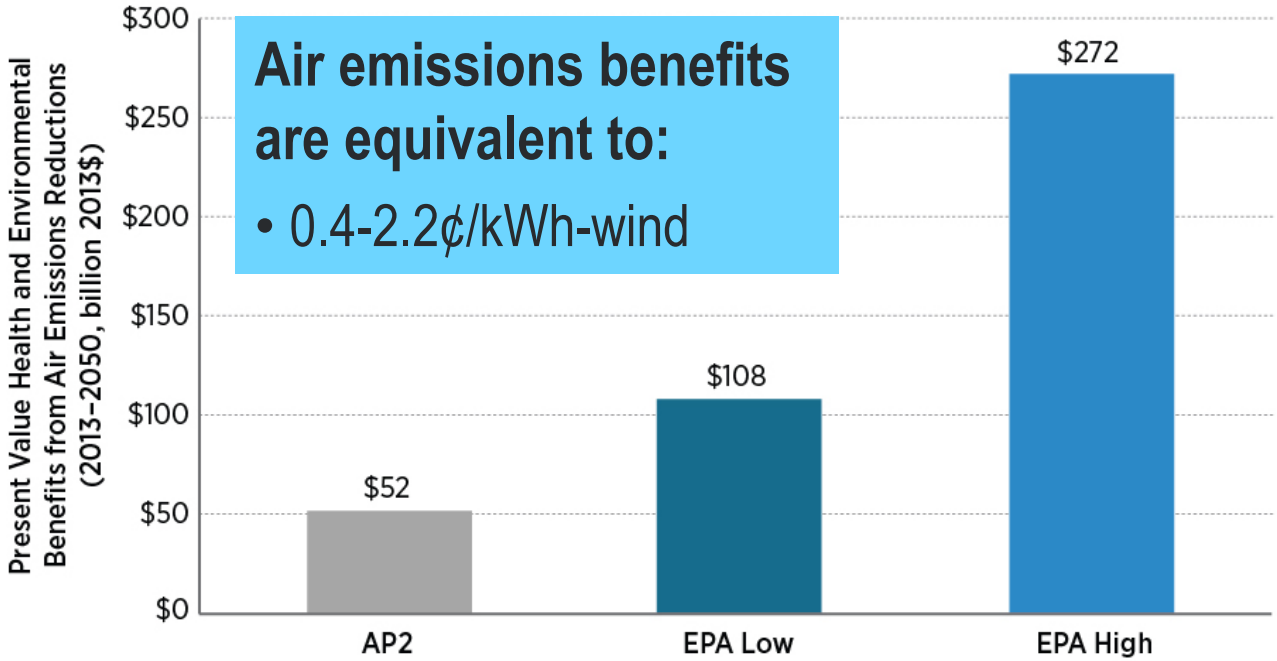
Wind Vision yields potential reductions in SO_2, NO_x, $PM_{2.5}$, creating health and environmental benefits that are estimated using multiple methods

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 reduced premature mortality





Air emissions benefits are equivalent to:

- 0.4-2.2¢/kWh-wind

The *Study Scenario* Reduces Power-Sector Water Withdrawal and Consumption

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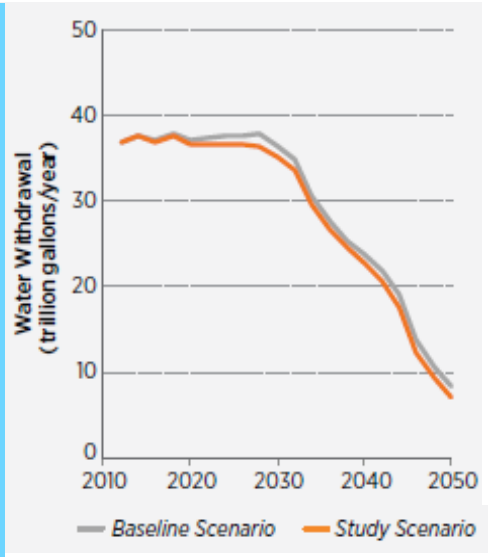
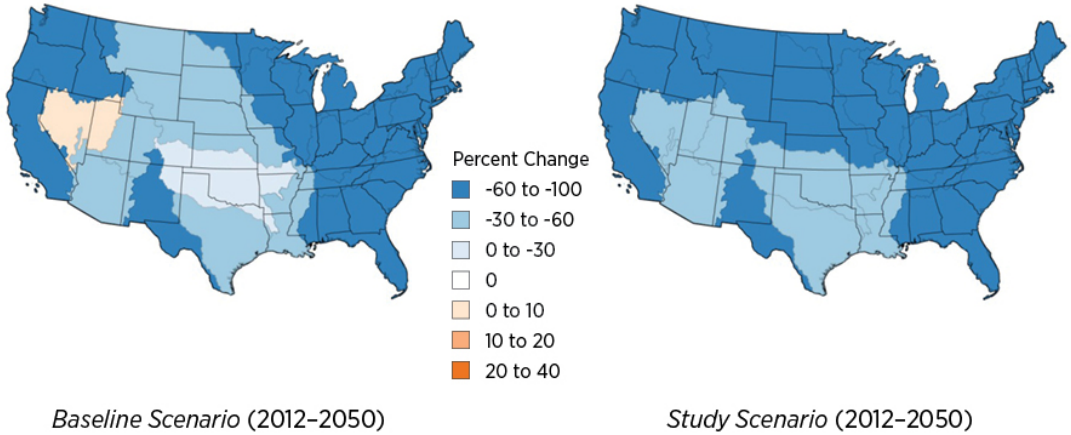
Wind Vision reduces water **withdrawals**:

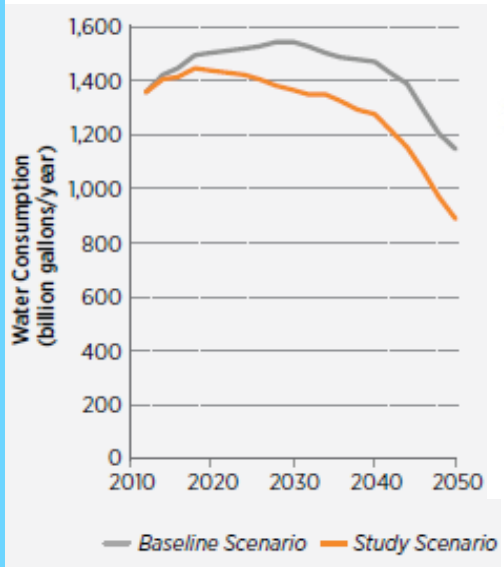
- 1% in 2020
- 4% in 2030
- 15% in 2050

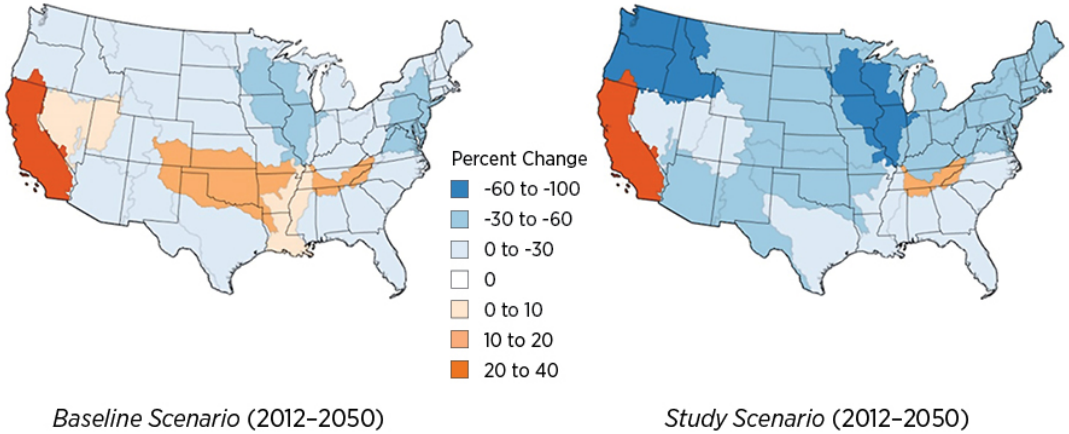




Wind Vision reduces water **consumption**:

- 4% in 2020
- 11% in 2030
- 23% in 2050





The *Study Scenario* Has Impacts on Electric Sector Fuel Price Risks and Natural Gas Prices

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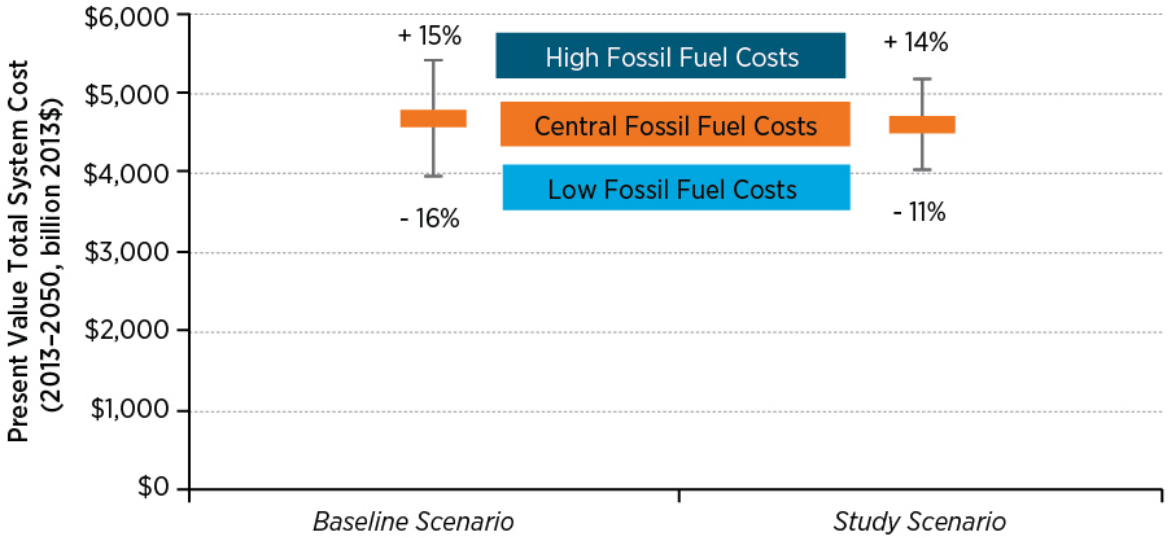
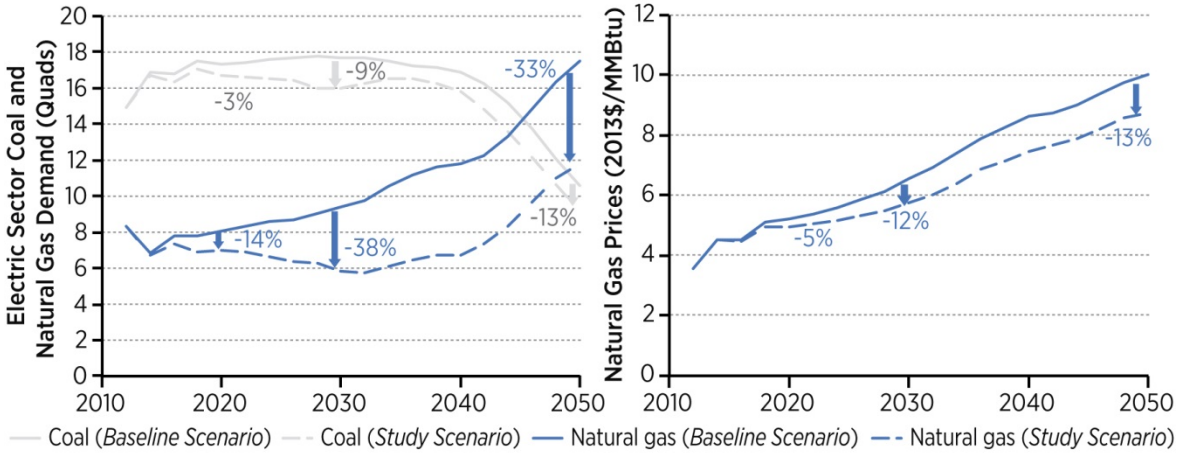
- Fuel price scenarios show that electric system costs under Wind Vision are **20% less sensitive** to long-term fluctuations in fossil fuel prices
- Lower natural gas demand in Wind Vision leads to lower gas prices; consumer benefits outside electric sector estimated at **~$280 billion**, on present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

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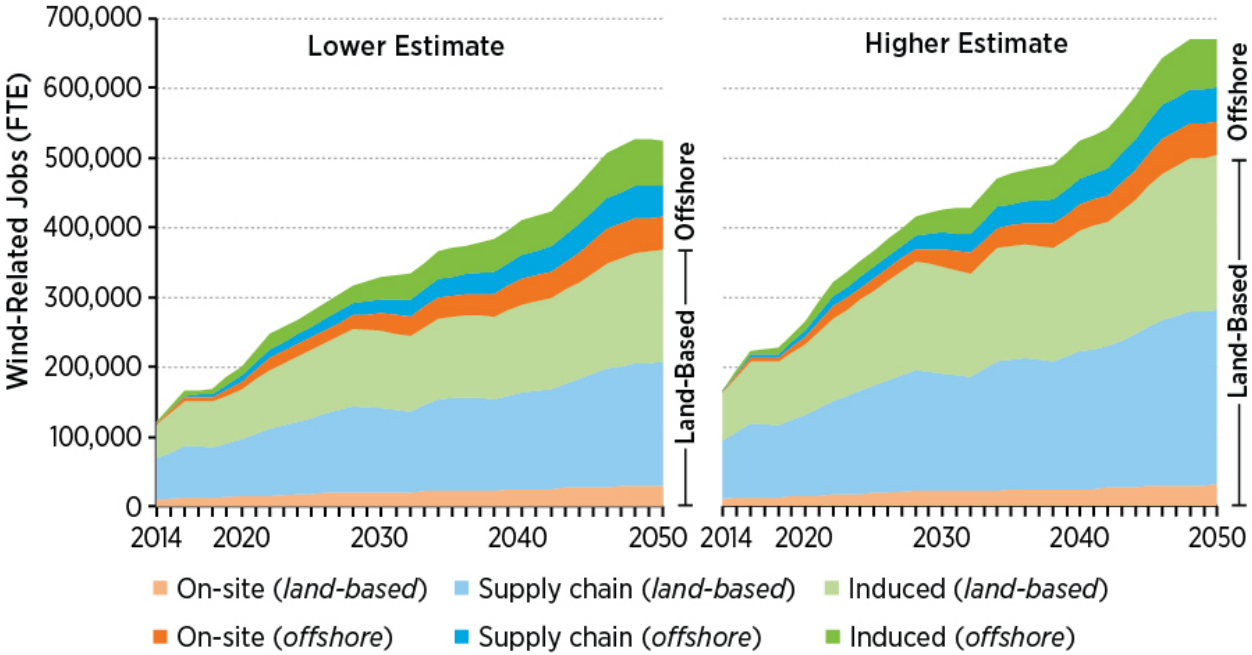

Component	Average Domestic Content (2013–2050) Lower	Higher
Towers	60%	90%
Blades	60%	90%
Nacelle components	20%	50%
Balance of plant materials	80%	95%
Labor (construction and O&M)	100%	100%
Replacement parts	30%	60%

Note: Offshore substructure and foundation costs are placed in the "Towers" category, above. Replacement parts include all parts replaced during scheduled and unscheduled maintenance.

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

NOTE: Study makes no claim about any possible net increases in jobs or economic development

Key Takeaways

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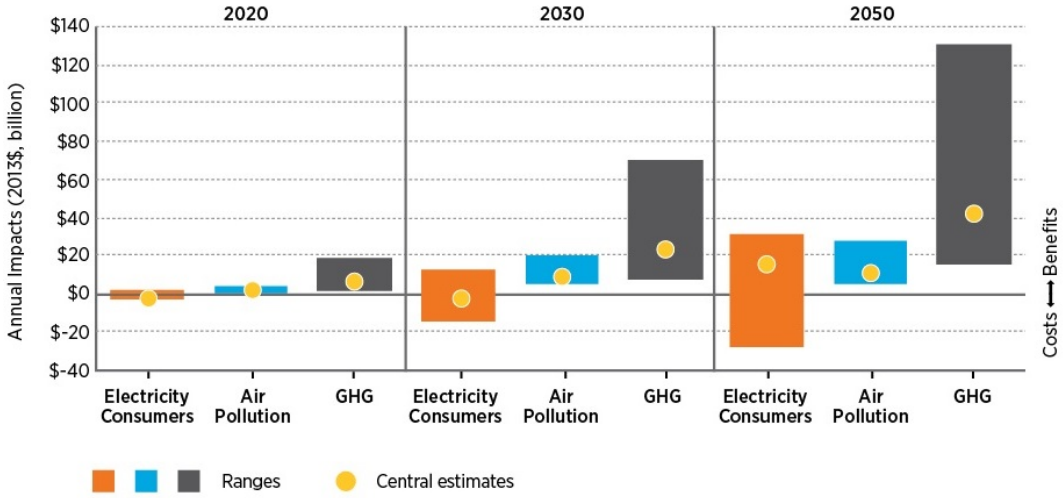
- A future where more than one-third of U.S. electricity demand is supplied by wind could support new wind power capacity additions that are consistent with the recent past and, ultimately, increased turbine demand due to repowering
- Electric systems impacts, including grid integration (with regional penetration of 55% by 2050, in some cases) and transmission challenges ($60B) are generally perceived to be manageable
- Increased electric system costs in 2020 and 2030 for the *Study Scenario* are offset by GHG, air pollution and other benefits; after 2030, high wind penetrations may be economic even without considering those benefits
- Realizing the *Study Scenario* requires aggressive cost reduction (40% by 2050), relatively high fossil fuel prices ($10-$12/MMBtu natural gas by 2040), and/or policy action
- Wind research and innovation remains critical to the continued viability of wind technology and reduces the long-term need for policy



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.

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Full DOE Wind Vision Report

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